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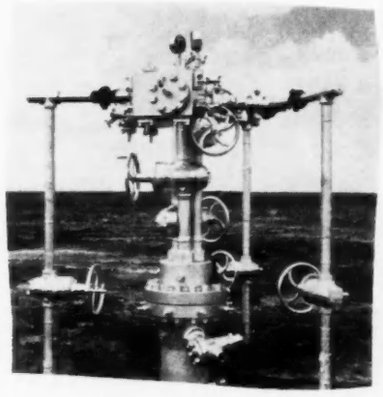
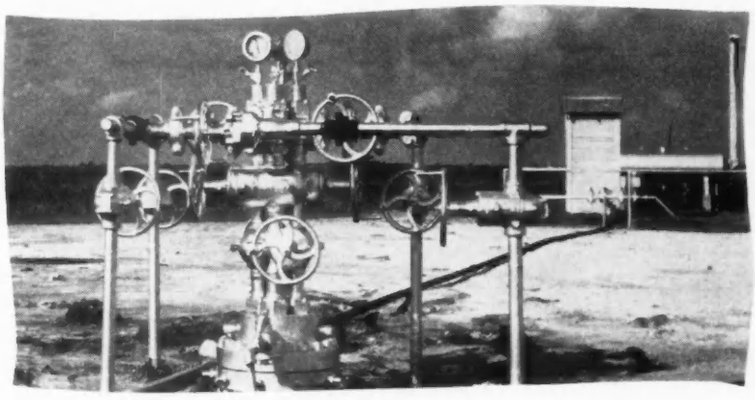


SMALL DIAMETER WELL COMPLETIONS



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Established 1916 as
The OIL WEEKLY®

A Gulf Publishing Company Publication

FOR EXPLORATION, DRILLING AND PRODUCING ENGINEERING OPERATIONS AND MANAGEMENT

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WORLD OIL published every month except semi-monthly in February and August. Second class postage paid at Houston, Texas.

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QUICK LOOK at this issue

To help you put first things first, scan these time-saving digests, checking those you want to read first.

☐ **Competing fuels air differences—seek common problems . . .** Twenty industry, legislative and academic authorities met in Washington, D. C., last month to candidly discuss areas of agreement and conflict in the competing fuels industries. Locale of the meeting was the Second Annual Energy Institute sponsored by American University. WORLD OIL was the only publication to send a representative to this important session—and the information obtained was timely and significant in this new era of industry-government relationships, as you will read, starting on ..... **Page 53**

☐ **Small diameter well completions (Part 1) . . .** Small cased wells have been successfully completed in almost all areas of oil and gas production operations, and trends indicate continued expansion of the method. This first of a comprehensive series of articles which will cover all phases of the technique, discusses terminology, economics, advantages, limitations, and the application of slim hole drilling techniques to small cased wells ..... **See Page 57**

☐ **How to upgrade lower Minnelusa plays with lithofacies maps . . .** This dual-purpose article evaluates oil and gas prospects of the lower Minnelusa (Pennsylvanian) formation in Wyoming, Nebraska, and South Dakota. It also shows the effective way in which prospective trends are identified through regional mapping of rock types showing quantities of sediments deposited, origin, environments, possible reservoir and petroleum source rocks, plus their relationships to one another. Not only are more geologists using and developing this mode of presentation, but more management people, even non-geologists, are also coming to understand and accept it ..... **Page 67**

☐ **How downhole rubber liners can help you . . .** Applications of unique retrievable tool include isolating thief zones in waterflood injection wells, protecting producing formation from fluid loss damage during well stimulation treatments and selectively squeeze cementing multiple zone dual completions. For other uses and a complete description of how the liner works, see **Page 73**

turn the page . . .

☐ **Can WOC time be reduced? . . .** Recent laboratory and field tests show that WOC time can be reduced—from the present accepted 24 hours to as little as 4-8 hours. For an information report on the laboratory and field results, plus reasons why reductions in WOC time are being recommended, turn to **Page 77.**

☐ **Evaluation of the heat wave process . . .** Variations of the basic heat wave process present a special challenge to the petroleum engineering profession. Some quantitative or at least semi-quantitative aspects of the process are known, but much is yet to be learned. This article describes results obtained to date in both laboratory and field work. Comments on specific case histories are included. For a complete wrap-up of the *in situ* combustion process to date, see .....**Page 89.**

☐ **Deeper gas pays spur Arkoma Basin activity . . .** Discovery of new gas pays under old fields has sparked a major gas play in southeastern Oklahoma and western Arkansas. For complete details on the 13-county area that has attracted both large companies and independents, turn to.....**Page 94,**

☐ **Natural gas utilization to begin in south Sumatra . . .** Standard-Vacuum Oil Company is to start the first large-scale production of natural gas in Indonesia for industrial purposes. Stanvac is committed to deliver from 12 to 15 MMcfd from Radja field in south Sumatra to a fertilizer plant to be built near Palembang by the Indonesian government. Hence, a petrochemical industry is being born in Sumatra. It may lead to more widespread use of gas in Indonesia in the future.....**Page 99.**

Where accuracy counts . . .

When evaluating company operations in the second half of 1961, major oil companies, equipment manufacturers, drilling contractors and independent producers will use the most complete, accurate and authoritative international report published:

WORLD OIL's International Outlook Issue

The 16th edition of this much sought after issue will contain:

- Outlook for the U.S. oil industry during the remainder of 1960.
- Detailed reports on political and economic trends in more than 110 countries.
- Production and drilling statistics for every oil and gas producing nation in the world.

. . . to be published August 15

Oil Industry In Brief

Outlook improves. Indiana Standard President John Swearingen predicts oil's economic picture will improve in last half of '61, compared with same '60 period—crude oil production will increase 3 percent, domestic product demand will rise 3 percent, product prices should hold fairly steady, and earnings will increase slightly.

Mid-East to get higher royalties? New upward pressure on Mid-East crude prices may result if countries win their bid for larger royalties at exporter's meeting in Iran August 17. Indications bid will be made come from Saudi Arab Oil Minister Taraiki who says added revenues would offset losses oil nations suffered when companies cut prices last year—losses which totaled $150 million in 1960, and will amount to $180 million in 1961.

API to take policy stand. Look for long-awaited policy stands on imports, depletion, natural gas regulation, etc., to be announced at American Petroleum Institute annual meeting in Chicago next November.

U.S. no longer No. 1 consumer? Chase Manhattan reports United States accounted for 50.9 percent of all petroleum consumed in Free World during 1960. However, indications are the United States will surrender its standing for the first time in 1961.

Gas wells increase. In the past five years, number of gas and gas condensate wells in the U.S. has increased 27 percent, from 74,261 to 94,617. In 1960, the total nearly equalled crude oil wells (8,361 vs. 10,444).

Inventories soar. At half-year mark, oil inventories were 20 million barrels higher than IPAA predictions, and 35 million barrels higher than year ago levels.

Demand down. Petroleum demand dropped 7.2 percent from year ago levels during June, and was off 2.5 percent during first half of 1961.

Imports drop. Crude and product imports started final six months down 13.7 percent from year ago, averaging 1.4 million barrels per day.

Why WORLD OIL readers are the 'best informed' on . . .

Technology. Starting with this issue, WORLD OIL presents Engineering Practices Report No. 4—the first complete how-to-do-it series to be published on small diameter well completions. You will find this series is much more than one or two experts' views on this significant engineering development. Instead, it is a compendium of ideas from many companies—brought together in one package after months of research, travel and personal contacts by the WORLD OIL editorial staff.

Economics. Later this month you will receive WORLD OIL's 16th Annual International Outlook Issue—the most complete, authoritative and sought after statistical report to be published on oil and gas industry economic progress in more than 100 countries.

New Management Ideas. In this issue, and in every issue, you have access to the most complete in-depth analyses of oil and gas industry events available—whether it be political actions affecting the industry, new management tools, prospective oil and gas areas, reports on industry conditions, or a "new look" at the competing fuels picture, starting on Page 53.

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R. B. Reilly, Circulation Manager, P. O. Box 2608, Houston 1, Texas, U.S.A. Single copies 50 cents (except special issues). Double prices for single copies more than a year old. Subscription rates: both foreign and domestic $2 a year.

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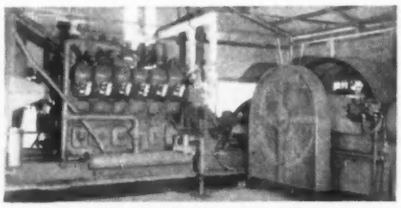

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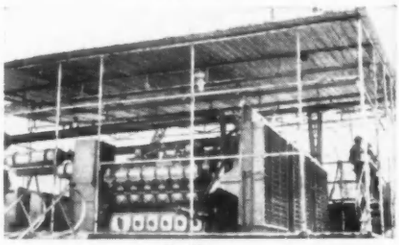

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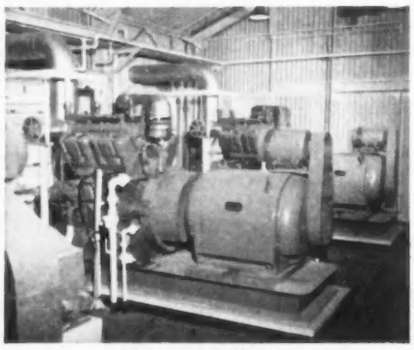

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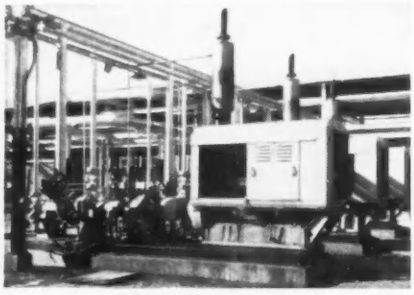

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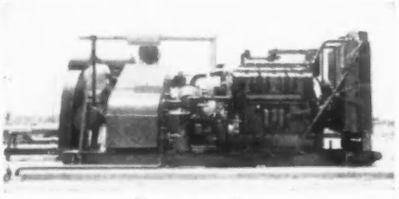

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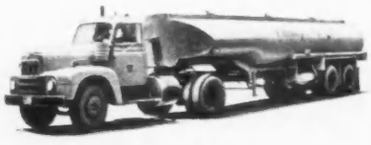

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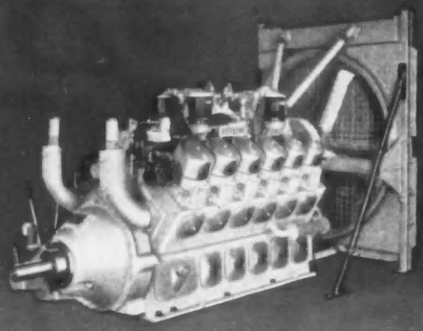
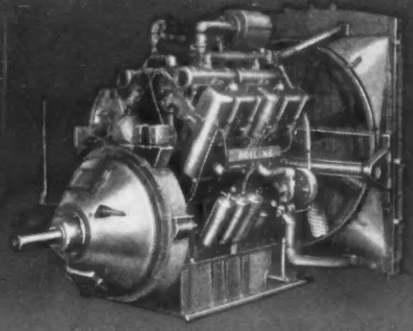
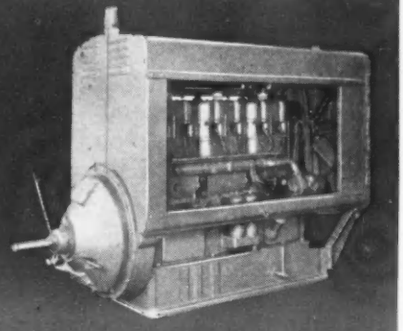


L-4000—12-cyl., 706 hp



H-2000—8-cyl., 310 hp



F-1500—6-cyl., 230 hp

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Looking Ahead

Completely "green" FPC staff by '62? . . . Compounding administrative confusion in the Federal Power Commission is sudden shake up in staff: Chairman Kuykendall has given up fight and is turning reins over to Joseph Swidler September 1, with strong indications he may resign in a few months . . . Sudden death of Commissioner Frederick Stueck created unforeseen vacancy, with speculation independent Republican Robert Weston, an FPC examiner, will fill post . . . So, with Swidler and Howard Morgan appointed to FPC in recent weeks, and former Oil and Gas Administrator Larry O'Connor in the throes of Senate confirmation, it is entirely conceivable President Kennedy will have a "green" five-member FPC staff before year is out—to tangle with morass of nearly 4,000 pending producer rate cases that would make the most experienced hand, stolid as he may be, want to chuck it all in complete frustration.

"Uncle Sam, please help us" . . . With coal in their hearts, West Virginia senators Byrd and Randolph have sent memorandum to Interior Secretary Udall, at his request, which includes these "S.O.S." signals:

- Check East Coast plants and military bases to see if they would be disrupted should tanker traffic be blasted out of the ocean in a national emergency.
- Expand coal research concerning liquefaction, coal-fired gas turbines, gasification, and coal pipe lines.
- Have government agencies make fuel selections from "fair and impartial" evaluation of fuel costs.
- Use all Interior Department facilities to find other ways to boost coal production to 500 million tons annually—as soon as possible.
- And, as usual, conduct study of energy resources.

Is this the way to stop our paternalistic government from expanding its ever-growing, tax hungry functions beyond all reasonable proportions?

News from the oil country . . . Bids will be opened August 15 on 3,254 acres of Oklahoma land within known geologic structures of existing fields. Bid forms for the 18 parcels, ranging from 640 to 4.5 acres, can be obtained from Bureau of Land Management manager, P. O. Box 1251, Santa Fe, New Mexico . . . Pennsylvania has passed conservation bill that includes spacing and pooling within a spacing unit, plus protection of correlative rights and unitization . . . New discovery in southern portion of Alaska's Kenai Peninsula was reported in July; Standard of Cal, et al's Falls Creek 1 flowed 1.95 MMcf gas per day from 7,600 feet . . . Six deep wildcats from 10,200 to 13,600 feet have been staked in Gulf area off Louisiana Coast . . . Notices to drill new wells in California totaled 992 during first six months, up 18.4 percent over 779 reported during same '60 period . . . Kingfisher County, Oklahoma, the nation's hottest drilling area at '61's beginning with 80 rigs operating, continues its blistering pace. Wildcat success ratio is 75 percent, with nearly 100 percent development well success. Current interest is in Mississippian Manning (6,780 feet), Red Fork Pennsylvanian (6,633 feet), and Meramec (7,020-7,090 feet) . . . Canada's northernmost well will be spudded next month, a 10,000-foot Arctic Island test 700 miles north of the mainland on Melville Island. To be drilled with crew of 25, including at least four Eskimos, the wildcat will test huge anticlinal structure believed to contain oil reserves similar to prolific Middle East structures.

Deep-seated salt domes detectable from analogued gravity data . . . New analog computer routines have been developed to provide more rapid detailed gravity data analysis. Light beam intensity on a surface, a function of square of distance from light source, represents normal gravity. Variations of actual gravity measurements from normal are rapidly determined from analog computer and recorded on punched tape. This high-intensity system is being used to analyze surveys in deep-seated salt dome areas in east Texas and south Louisiana.

Good Wells Make Good News

Recent Acid Treatments that Solved Special Production Problems

August 1, 1961

Here are four recent treatments that show how Dowell uses job-tailored materials and engineered treatment planning to help operators solve production problems.

- **Alberta, Canada** (Old Oil Well) This well had been producing from the D-3 through perforations between 5980 and 5992 feet. When production dropped to 30 bopd, operator perforated two upper intervals: 5928 to 5940 feet and 5963 to 5976 feet. Original perforations were closed off temporarily with Dowell diverting agent and the new intervals were acidized with 2000 gallons 28 percent Dowell acid containing a wetting agent. Ten ball sealers were injected after each five barrels of acid. Injection rate was 2 - 2½ bpm at 1760 - 2250 psi. Two weeks after treatment production was 68 bopd.

- **Park County, Wyoming** (New Oil Well) This well was completed into the 98-percent-soluble Madison lime at about 5000 feet. Treatment was engineered by Dowell using the Acid Guide*. 10,000 gallons acid-oil-emulsion type Retarded Acid, containing FLA* fluid loss additive, was injected at 8.5 bpm. 70 days after treatment, production had stabilized at 212 bopd and 187 bwpd -- above average for wells in the same field which had been treated with regular acid.

- **Lamar County, Mississippi** (Old Oil Well) Well was producing 35 bopd and 200 bwpd through perforations between 8644 and 8822 feet in the Tuscaloosa sand. Operator wanted to open up more of the section and improve oil production. Dowell treated using acid and diverting agent in stages. Twelve barrels of diverting agent were followed by seven six-barrel stages of acid. Three barrels of diverting agent were injected between each acid stage. Well came back making 102 bopd and 44 bwpd -- a good production increase plus a greatly improved water/oil ratio.

- **Gray County, North Texas** (Old Oil Well) This well was completed open-hole and shot with nitro in 1959. Production from the Dolomite lime, at 2961 to 3120 feet, had declined to three bopd. Well failed to respond to a large frac treatment. After Dowell acidized with 2000 gallons Stabilized Acid, production levelled off at more than 11 bopd. Operator was more than pleased with results.

Let a Dowell engineer help you select a treatment designed to solve your production problems profitably. Dowell services and products are offered in North and South America, Europe, North Africa and Iran. Dowell, Tulsa 14, Oklahoma.

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What are you worth?

WHAT DETERMINES YOUR VALUE to your company? How can you increase that value so your contribution can be worth more to you and your company?

Libraries have shelves full of material about ways to assure continuing success. After studying much of this material, you probably will decide that the answers lie in your own individual outlook and effort.

Recently, Dr. Thomas Stelson, head of the civil engineering department of the Carnegie Institute of Technology was quoted in the National Society of Professional Engineers *Newsletter* as saying "The reason starting rates creep up on salaries paid to more experienced engineers is because recent graduates are worth as much or more than many older men." he added that **unless engineers devote a considerable portion of their time to keeping abreast of their field, they quickly are left behind and lose their value to industrial employers.**

Basing his estimate on changes in the Carnegie curriculum over the past 10 years, Dr. Stelson said that **an engineer who wants to increase his value at a reasonable rate has to devote about one-third of his productive hours to self-education and improvement.** Progress will leave an engineer behind the times unless he keeps abreast of the developments.

And to make matters worse, Dr. Stelson noted that the trend toward engineers winding up unemployed or working in subprofessional capacities is worsening. "Such a trend implies that a new engineering graduate is near the peak of value to his employer and society, and that several years of experience may only add slightly to his professional stature," Dr. Stelson explained.

* * *

WHAT CAN YOU, as an individual, do about the problem? How can you insure that you will be worth as much 10 or 20 years from now?

Dr. Stelson outlined several solutions in recommending improvements in under-graduate training, increased emphasis on graduate education, better on-the-job training, study leaves, and exchange of ideas through professional societies.

Unfortunately, some of these "insurance" avenues are not immediately or continuously available. But one additional means of keeping abreast of the changing times IS immediately and continuously available—regular reading of technical operating publications which consistently publish in-depth articles on new technological developments and techniques.

That is where WORLD OIL comes in. WORLD OIL, as any other publication, cannot publish all of the petroleum industry information. **So it publishes only the best.**

In fulfilling its purpose as a technical-operating publication devoted to the petroleum industry, WORLD OIL publishes periodic engineering practices reports, in-depth treatment of economic and technical subjects, plus a continuing monthly menu of the latest significant engineering developments in exploration, drilling and production. Because of this, WORLD OIL **may be likened to the "latest chapter in the engineer's continuing textbook on technology."**

A regular WORLD OIL reader knows he can depend on receiving each month a publication that provides him with information that keeps him abreast of:

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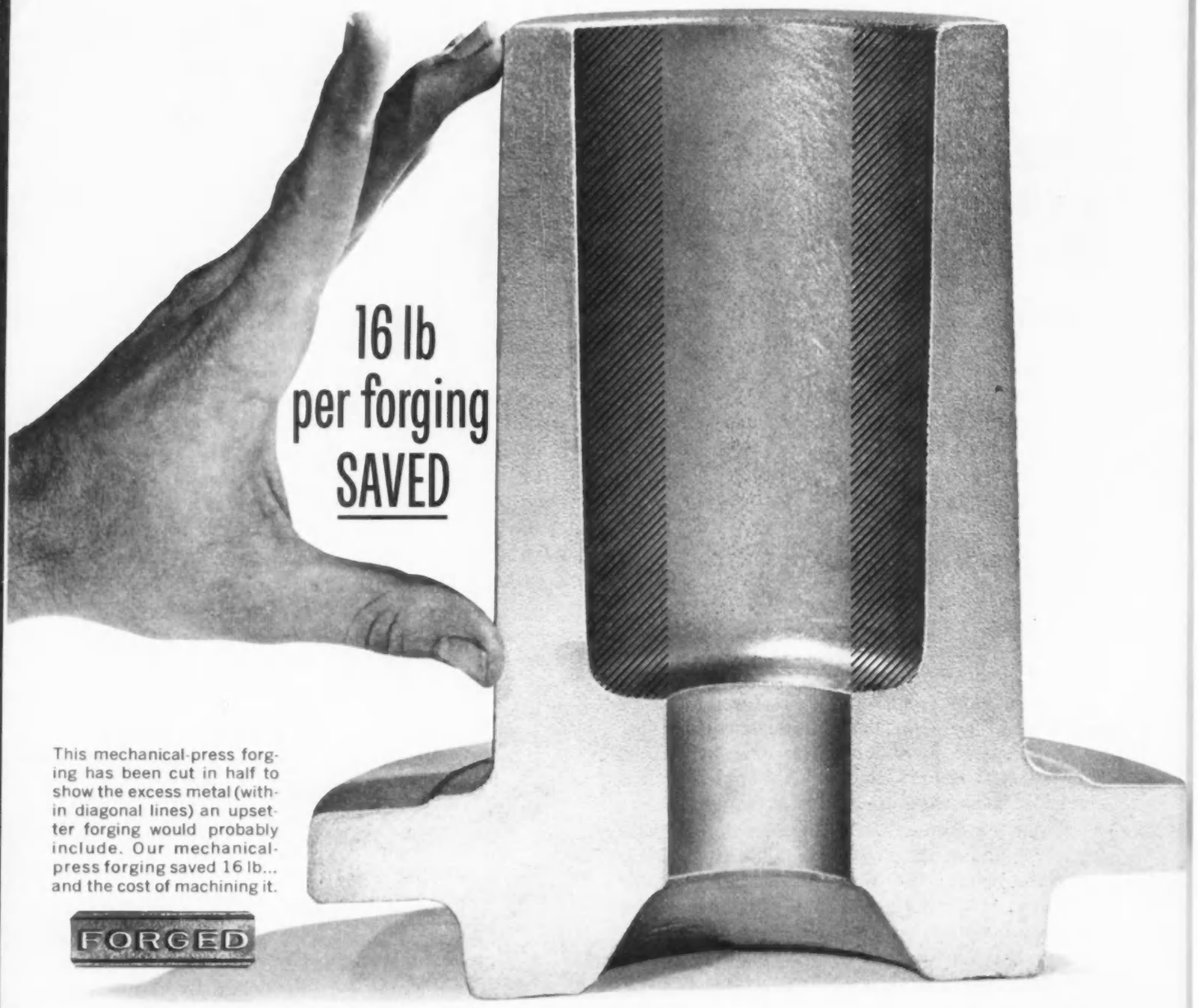
- Information about related phases of his industry.
- A continuing flow of money-making ideas.

This leaves the myriad of non-technical, non-operating developments to the many other mediums of information available to the engineer. WORLD OIL's editorial program is aimed squarely at serving his technical operating needs in a detailed manner.

That, our subscribers have told us, is the best way they can be served. And it is one of the best ways *immediately and continuously available* for an engineer to assure himself and his employer that not only is he worth just as much as when he was hired but also that his worth is increasing.

Donald E. Kliewer


16 lb
per forging
SAVED
This mechanical-press forging has been cut in half to show the excess metal (within diagonal lines) an upsetter forging would probably include. Our mechanical-press forging saved 16 lb... and the cost of machining it.
FORGED

thanks to ingenuity and a mechanical press

Most shops would make this forging (a cone drive gear) the *conventional* way—on an upsetter. The forging would weigh 73¾ lb.

Bethlehem, using a little ingenuity, makes it on a mechanical press. The forging weighs only 57¾ lb.

There's a 16 lb difference. 16 lb of steel our customer doesn't pay for . . . or pay to machine away.

When you make a forging on an upsetter, you're limited to punching through with a straight hole. When you make a forging on a mechanical press, you can (if you know how) forge closely to the final shape. This saves our customer a lot of metal and a lot of machining.

Why then couldn't *any* forge shop handle this job? For two reasons: (1) Not every forge shop is equipped with a mechanical press. (Bethlehem has 6.) (2) Not every forge shop is staffed with craftsmen who can make a mechanical press do tricks. (Our shop is; our men can.) Try us. You'll like the savings.

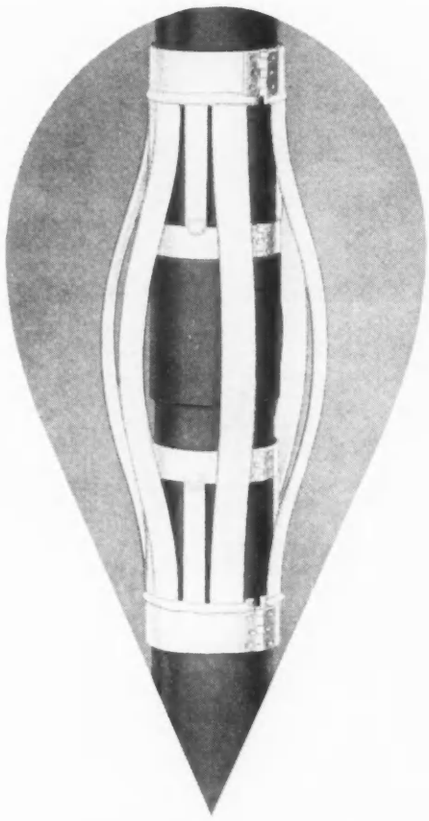
Steel

for Strength
. . . Economy
. . . Versatility

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

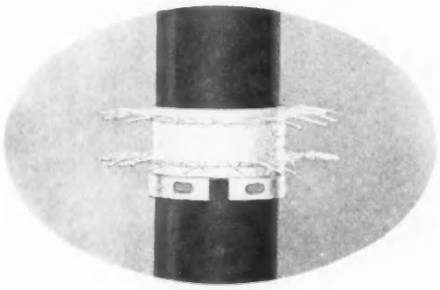
BETHLEHEM STEEL

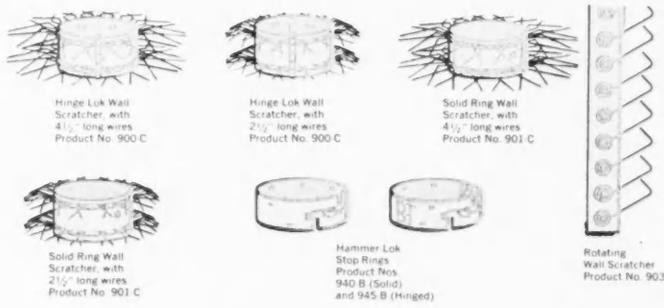
BETHLEHEM STEEL



"G-12" Slim Hole Casing Centralizer Product No. 910 G
"HN-20" Solid Ring Casing Centralizer Product No. 908 HN
"H-20" Hinge Lok Casing Centralizer Product No. 9112
Hinge Lok Rigid Casing Centralizer Product No. 9133
"HN-15" Solid Ring Casing Centralizer Product No. 908 HN
"H-15" Hinge Lok Casing Centralizer Product No. 9115
"H-25" Hinge Lok Casing Centralizer Product No. 9113

A good cement job starts with two things




Hinge Lok Wall Scratcher, with 4½" long wires Product No. 900 C
Hinge Lok Wall Scratcher, with 2½" long wires Product No. 900 C
Solid Ring Wall Scratcher, with 4½" long wires Product No. 901 C
Solid Ring Wall Scratcher, with 2½" long wires Product No. 901 C
Hammer Lok Stop Rings Product Nos. 940 B (Solid) and 945 B (Hinged)
Rotating Wall Scratcher Product No. 903

A good primary cementing job starts with centered casing and a good bonding surface. The only centralizers and scratchers good enough for this important job are the best ones you can get. That's where Baker comes in...

BAKER CENTRALIZERS are tough and resilient to withstand running-in forces. They are made in a wide range of spring-bow heights to provide one exactly right for your specific casing program. That's why when you're landed your casing has adequate clearance for good cementing. For installation convenience, Baker Centralizers come in both Hinge-Lok and Solid-Ring types.

BAKER SCRATCHERS glide down the hole without disturbing the mud cake; and when activated in the cementing area they dig in and remove the mud cake ensuring a good bonding surface. Baker Reciprocating Scratchers come with either long or short wires, in Hinge-Lok or Solid-Ring types. Baker Rotating Scratchers come in five-foot sections, and feature "plow angle" scratcher wires that are effective regardless of annular clearances.

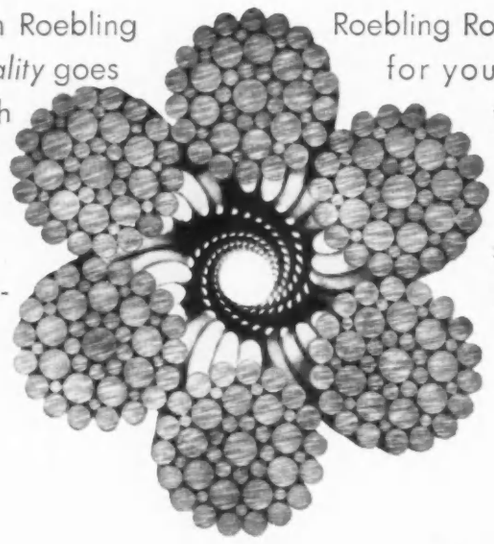
NO WELD INSTALLATIONS of centralizers and scratchers are easier and better with Baker Hammer-Lok Stop Rings. Just a hammer blow locks one on. And they stay put because inserted teeth give them a much stronger grip than other friction-type stop rings.

Baker Primary Cementing Equipment is conveniently available at Supply Stores in the United States and Canada.

BAKER
CENTRALIZERS • SCRATCHERS

BAKER OIL TOOLS, INC.
HOUSTON / LOS ANGELES / NEW YORK

Profit from the inside story on Roebling Royal Blue Wire Rope—the *quality* goes all the way through. Extra high strength in conjunction with uniformity of rope construction means unequalled resistance to wear and tear — and a whopping increase in service life. That is why every inch of Roebling Royal Blue pays off on the job for you. Get all the details from your wire rope distributor, or write for free booklet to Roebling's Wire Rope Division, Trenton 2, New Jersey.



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Branch Offices in Principal Cities
John A. Roebling's Sons Division
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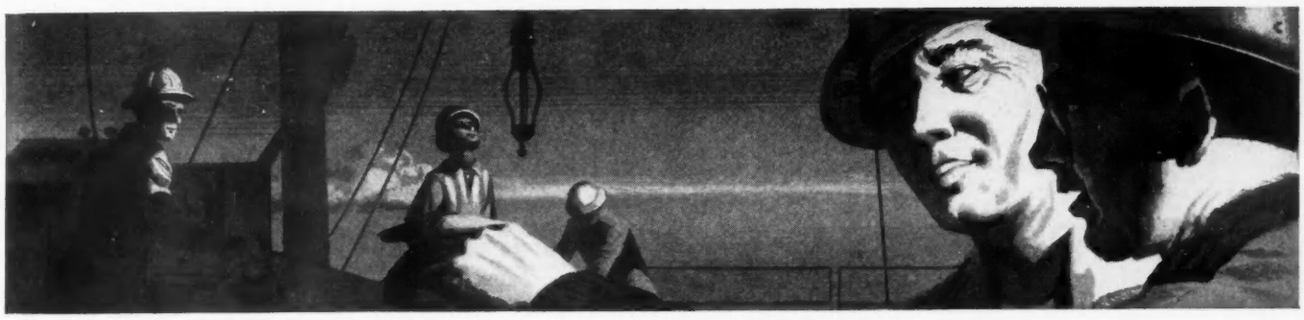
Quality inside and outside

We put a lot of work into it — You get a lot of work out of it



Several thousand success stories speak for Baker Retrievable Bridge Plugs and the men who run them...

PRODUCT NO. 677-C

Why a retrievable bridge plug in the first place? The reason was a compelling one – there was a need to save time and money on certain important operations *(see right)*.

So a few years ago, Baker developed a new kind of bridge plug. Today, several thousand successful jobs later, Baker Retrievable Bridge Plugs have proved themselves to the satisfaction of operators the world over.

There's a reason for this success. Baker engineers have just one business – and that is designing oilwell tools. Likewise, Baker Servicemen have but one business – and that is running Baker tools. These are the things Baker concentrates on.

Superior tools and professional tool specialists to run them – it's a hard combination to beat. That is why so many operators look to Baker for tools and service.

The Facts About Baker Retrievable Bridge Plugs

WHY RETRIEVABLE BRIDGE PLUGS?

Baker designed them to fill a need for bridge plugs that could be set or reset any number of times without coming out of the hole. Without retrievable plugs, drill-up time alone would be a formidable cost factor in certain operations *(see below)*.

HOW THEY WORK

1 A Baker Retrievable Bridge Plug is run in on the Baker Full Bore Cementer – or by itself on wire line or tubing. Large bypass valves let it run freely.

2 Operation is simple and positive. Once in the hole and released, it sets and packs off automatically – no rotation is required.

3 Packoff is dependable. Two packing cups and two opposed sets of rocker slips hold pressure from either direction. When pressure differential reverses, the packoff reverses automatically.

WHERE AND HOW THEY ARE USED

1 They do many jobs. They see the most action in fracturing, acidizing, and squeeze cementing operations where they are teamed with the Baker Full Bore Cementer.

2 These are the bridge plugs that made conventional straddle tools obsolete. A Baker Retrievable Bridge Plug and a Full Bore Cementer can straddle virtually unlimited distance.

3 Because these plugs are so easy to pick up and relocate, any number of zones can be tested and treated in one round trip.

4 They are also used alone wherever a temporary plug is required down-hole.

5 They are used to plug off just below surface to keep the well under control when working over or testing well head equipment.

6 They are kept available as emergency equipment for offshore wells.

ARE BAKER PLUGS SUPERIOR?

For one thing, Baker Retrievable Bridge Plugs have two sets of opposed rocker type slips. In Baker's opinion, a retrievable bridge plug needs this extra holding power. Moreover, the plug is self-setting. Setting requires neither rotation nor pulling. Note this, too: the bypass valves have no ports or slots to plug up with mud, sand, or junk. They are full-opening 360° valves. These bridge plugs are simple in design, and are simple to operate. That is why they adapt with easy flexibility to the performance of many important operations.

BAKER

RETRIEVABLE BRIDGE PLUGS

BAKER OIL TOOLS, INC.

HOUSTON
LOS ANGELES
NEW YORK

For more data on advertised products, use cards, last page.

Oil supplies too large for lagging demand

THE PETROLEUM INDUSTRY'S situation deteriorated in June, as demand for all major products except kerosine ran lower than last year. Current supplies of oils were not curtailed in line with the low demand, and total stocks of refined products were increased much more heavily than the moderate accumulation of June last year. The large build-up of products storage occurred as crude runs to stills were almost as high as in June last year, despite a need for curtailment.

A natural consequence of the excessive new supply and accumulation of surpluses in storage has been a weakening of markets for products.

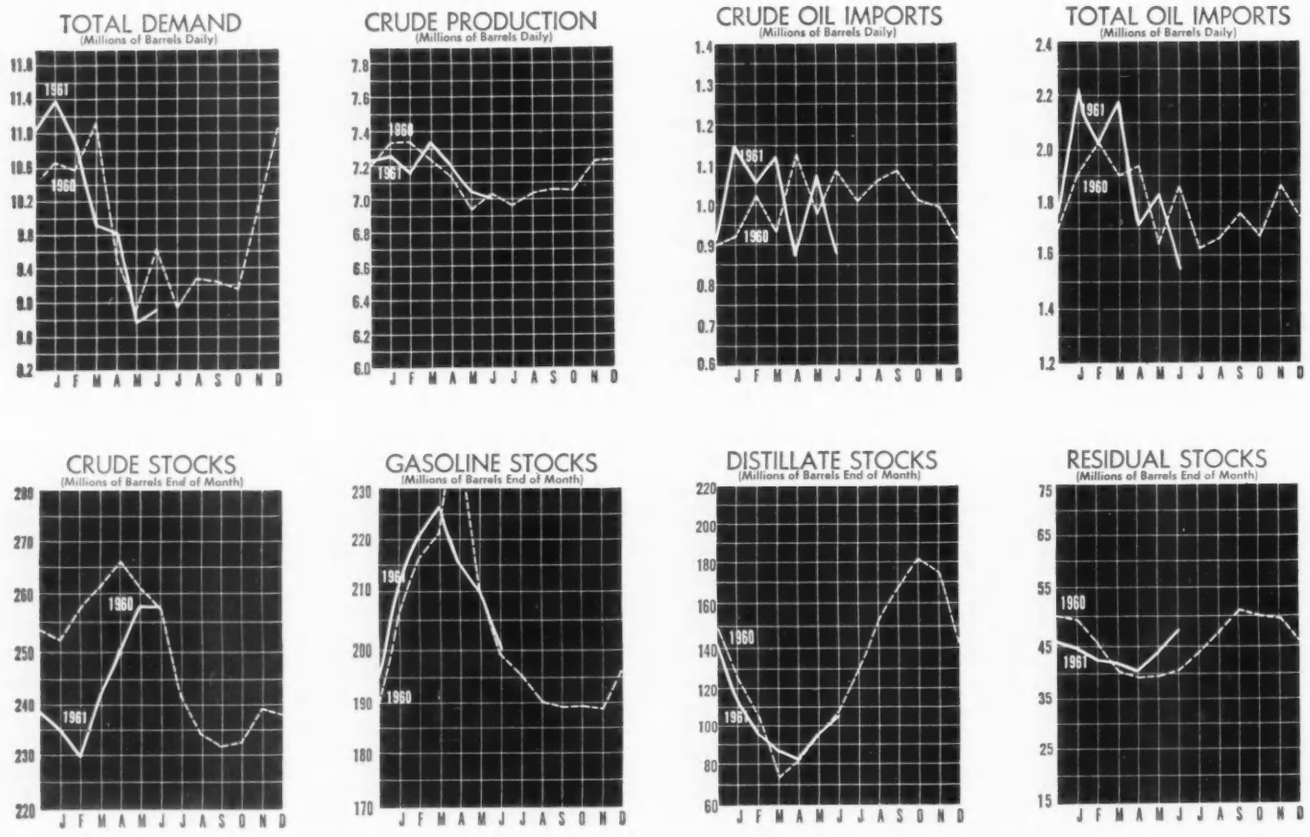
Gasoline, the industry's major product, has been hit by the unfavorable supply-demand situation, and gasoline price wars have continued or spread. Gasoline demand was off 4.1 percent in June and off nearly 1 percent for the first half of this year.

Gasoline stocks have not come down as much as desirable in this summer season. At the end of June they totaled 200 milion barrels and were 2 million higher than one year earlier. This fact reflected deterioration in June. For at the end of May they were the same as one year previously.

Distillate fuel oil stocks also showed a worsening trend in June. Stocks of 113 million barrels June 30 were 4 million barrels above one year before, whereas the stocks of 94½ million barrels May 31 were the same as a year earlier. Demand for this product is quite seasonal and dependent on weather conditions. And so the weather must have accounted for a part of the sharp drop of 13.8 percent in distillate fuel oil demand in June 1961, compared with June last year. However, distillate demand for the first half of this year was off 1 percent from last year.

Residual. Trends for residual fuel oil have been similar to those for distillate fuel. Demand has been lagging, and stocks have been growing more excessive. The demand for residual was off 9.3 percent during June, and it was down 5.8 percent for the first half of this year. This product is sensitive to industrial activity, being used

Petroleum Trends...



Don't let its compact size fool you

This Baker Model "A" Retrievable Tension Packer is a versatile performer —and it's economical

Just how versatile is the Model "A"? You can use it for waterflooding. For simple frac or acidizing jobs in shallow or low fluid wells. In wells with damaged or defective casing where retrievability of any packer would be doubtful. And many other uses.

In fact the Model "A" is about as versatile as your needs are varied. You can set and reset it as often as you want, in a single trip. And you can use it over and over because it's built to last. It's easy to maintain, and parts are available from convenient Baker stocks.

Can you rely on a packer so compact and economical? You can. The Model "A" is simple in design. It contains proven Baker components, such as rocker-type slips, performance-proved packing element, *and two separate safety release systems.*

Learn more about this hard-working packer. Ask your Baker man for Bulletin 334. Or, write Baker Oil Tools, Inc., P.O. Box 2274, Terminal Annex, Los Angeles 54, California.

BAKER

MODEL "A"
TENSION PACKER

BAKER OIL TOOLS, INC. HOUSTON | LOS ANGELES | NEW YORK

Product 739-A

U.S. Petroleum Demand and Supply (Thous. Bbls. Daily)

ITEM	June 1961	June 1960	% Diff.	May 1961	January-June 1961	January-June 1960	% Diff.
DEMAND							
All Oils, Total Demand	8,915	9,606	— 7.2	8,788	9,805	10,051	— 2.5
Domestic Demand	8,735	9,353	— 6.6	8,618	9,631	9,835	— 2.1
Export Demand	180	253	—28.9	170	174	216	—19.5
Gasoline, Total Demand	4,483	4,674	— 4.1	4,264	4,065	4,099	— 0.8
Distillate, Total Demand	1,176	1,364	—13.8	1,428	2,058	2,076	— 0.9
Kerosine, Total Demand	256	223	+11.5	256	385	360	+ 6.9
Residual, Total Demand	1,249	1,377	— 9.3	1,381	1,624	1,724	— 5.8
Other Oils, Total Demand	1,751	1,968	—11.0	1,459	1,673	1,792	— 6.7
CHANGE IN STOCKS							
All Oils, Change in Stocks	+643	+95	.....	..1,045	+322	—162	.....
NEW SUPPLY							
Total New Supply	9,558	9,702	— 1.5	9,833	10,127	9,889	+ 2.4
Domestic Production, Total	7,970	7,828	+ 1.8	8,009	8,214	8,001	+ 2.7
Crude Oil	7,035	6,939	+ 1.4	7,059	7,232	7,070	+ 2.3
Natural Gas Liquids	935	889	+ 5.2	950	982	931	+ 5.5
Imports, Total	1,588	1,874	—15.3	1,824	1,913	1,888	+ 1.3
Refined Products	704	783	—10.1	737	902	873	+ 3.3
Crude Oil, Total	884	1,091	—19.0	1,087	1,011	1,015	— 0.4
Crude, East of California	656	800	—18.0	765	733	757	— 3.2
CRUDE RUNS							
Crude Runs to Stills	8,022	8,126	— 1.3	8,020	8,127	8,052	+ 0.9
Domestic Crude	6,999	7,047	— 0.7	7,051	7,117	7,051	+ 0.9
Foreign	1,023	1,079	— 5.2	969	1,010	1,001	+ 0.9

U.S. Stocks of Oils (Million Bbls. at End of Month)

KIND OF OIL	TOTAL IN U.S. June 1961	TOTAL IN U.S. June 1960	% Diff.	TOTAL IN U.S. May 1961	EAST OF CALIFORNIA June 1961	EAST OF CALIFORNIA June 1960	% Diff.	EAST OF CALIFORNIA May 1961
All Oils	816.0	779.5	+ 4.7	796.7	.....	.....	.....	.....
Crude Oil	257.4	257.3	.....	257.3	230.1	223.6	+ 2.9	227.7
Natural Gas Liquids	38.5	29.4	+31.0	35.0	.....	.....	.....	.....
Gasoline	200.1	198.4	+ 0.8	210.5	174.0	168.0	+ 3.6	183.9
Distillate Fuel Oil	113.1	109.2	+ 3.6	94.5	99.5	98.1	+ 1.4	82.2
Kerosine	29.8	27.3	+ 8.8	27.7	28.3	26.0	+ 8.8	26.2
Residual Fuel	47.6	41.1	+15.8	44.7	29.2	28.4	+ 2.8	28.6
Other Products	129.5	116.8	+10.9	127.0	.....	.....	.....	.....

U. S. Crude Oil Production, by States (Thous. Bbls.)

STATE or DISTRICT	Daily Average for Month June 1961	June 1960	% Diff.	May 1961	Total, January-June 1961	1960	% Diff.
Alabama	19.3	21.6	— 10.7	19.3	3,604	3,380	+ 6.6
Arkansas	77.3	77.4	— 0.1	81.6	14,949	14,232	+ 5.0
California	820.3	837.4	— 2.1	824.5	149,586	151,496	— 1.3
Colorado	128.4	128.2	+ 0.2	129.5	23,656	23,292	+ 1.6
Florida	1.1	0.9	+ 22.2	1.1	192	195	— 1.5
Illinois	213.6	219.6	— 2.7	212.1	38,813	39,232	— 1.1
Indiana	30.7	30.4	+ 1.0	30.4	5,586	5,737	— 2.6
Kansas	304.8	302.9	+ 0.6	310.0	56,234	55,961	+ 0.5
Kentucky	50.8	61.3	— 17.1	50.1	9,274	11,008	— 15.8
Louisiana	1,146.1	1,040.1	+ 10.2	1,159.1	208,608	194,389	+ 7.3
North	110.8	128.9	— 14.1	110.3	22,422	22,654	— 1.0
South	1,035.3	911.2	+ 13.6	1,048.8	186,186	171,735	+ 8.4
Michigan	53.8	41.9	+ 28.4	53.0	9,711	6,664	+ 45.7
Mississippi	149.9	140.2	+ 6.9	150.2	27,050	25,812	+ 4.8
Mo.-So. Dak.-Tenn.	0.7	0.6	+ 16.7	0.7	169	161	+ 5.0
Montana	87.3	80.8	+ 8.0	82.0	15,065	14,843	+ 1.5
Nebraska	68.3	68.3	.....	67.0	12,513	11,657	+ 7.3
Nev.-Wash.-Alaska-Ariz.	17.0	1.0	+1,600.0	14.8	2,170	137	+1,483.9
New Mexico	305.7	291.9	+ 4.7	311.9	55,710	53,977	+ 3.2
Southeast	268.6	246.3	+ 9.1	276.8	48,138	45,586	+ 5.6
Northwest	37.1	45.6	— 18.7	35.1	7,572	8,391	— 9.8
New York-Pennsylvania	20.2	23.7	— 14.8	20.5	3,647	4,071	— 10.4
North Dakota	56.8	60.8	— 6.6	52.8	10,946	10,187	+ 7.5
Ohio	12.0	14.0	— 14.3	12.5	2,352	2,503	— 6.0
Oklahoma	501.6	512.6	— 2.1	528.5	96,787	97,714	— 0.9
Texas	2,476.7	2,502.2	— 1.0	2,459.3	471,835	475,951	— 0.9
Dist. 1: South Central	45.9	45.1	+ 1.8	46.3	8,438	8,035	+ 5.0
Dist. 2: Middle Gulf	107.0	108.4	— 1.3	106.3	20,730	21,363	— 3.0
Dist. 3: Upper Gulf	336.4	349.7	— 3.8	337.9	63,973	65,956	— 3.0
Dist. 4: Lower Gulf-S.W.	187.4	179.8	+ 4.2	181.4	34,925	34,743	+ 0.5
Dist. 5: East Central	26.8	26.6	+ 0.8	26.8	5,022	5,018	+ 0.1
Dist. 6: Northeast	241.6	233.9	+ 3.3	237.5	46,043	45,752	+ 0.6
Dist. 7-B: North Central	121.4	126.1	— 3.7	120.9	22,990	23,708	+ 3.0
Dist. 7-C: West Central	113.5	119.7	— 5.2	112.3	21,436	22,757	— 5.8
Dist. 8: West	1,000.5	964.0	+ 3.8	992.7	191,222	188,822	+ 1.3
Dist. 9: North	191.1	198.1	— 3.5	194.3	35,234	35,509	— 0.8
Dist. 10: Panhandle	105.0	107.9	— 2.7	102.9	19,015	19,778	— 3.9
Utah	93.2	105.3	— 11.5	88.0	17,129	19,455	— 12.0
Virginia	.....	.....	.....	.....	2	3	— 33.3
West Virginia	6.9	6.9	.....	6.7	1,205	1,120	+ 7.6
Wyoming	392.0	369.1	+ 6.2	393.3	72,282	63,515	+ 13.8
Total United States	7,034.5	6,938.7	+ 1.4	7,058.9	1,309,075	1,286,692	+ 1.7

Sources for above 3 tables: Bureau of Mines monthly reports except last two months based on API and B. of M. weekly reports and WORLD OIL estimates and Texas districts from API.

extensively as fuel for industrial purposes. Lagging of demand consequently has reflected the business recession. But it also may have reflected some loss of business to natural gas.

Stocks of residual fuel oil at the end of June were 6½ million barrels greater than on June 30 last year. At the close of May this year they had been only 5.1 million barrels above a year previously.

Bright star. Kerosine remains the conspicuous bright star in the industry's firmament. Demand continues to increase, as growing quantities are consumed to fuel expanding fleets of commercial jet planes. The demand for kerosine in June 1961 was 11.5 percent greater than in June last year, while other products of the industry were showing substantial decreases. For the first half of this year, kerosine demand was up almost 7 percent.

Stocks of kerosine have been no problem, with demand so strong. Kerosine stocks June 30 were 2½ million barrels above one year earlier in totaling 29.8 million barrels. They were similarly above a year ago on May 31. But more demand justifies more stocks.

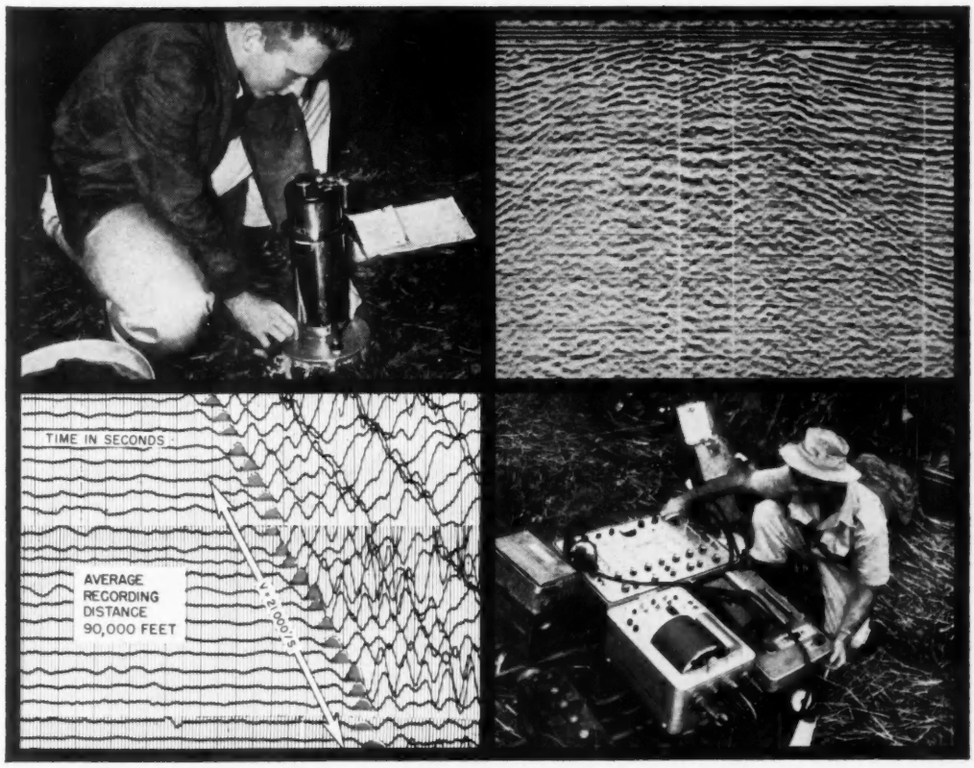
Total demand for petroleum was off 7.2 percent from last year during June, and it was down 2.5 percent for the first half of this year. Prior to June the demand for this year was off only 0.7 percent.

Trends of new supply have failed to conform with the pattern of lagging demand. Total new supply was down from a year ago by only 1.5 percent in June. And for the first half of this year, it was up 2.4 percent, in the face of reduced demand.

For the excesses of oils this year, all sources of new supply may be blamed. Production of natural gas liquids showed increases of 5.2 percent in June and 5.5 percent for the first half of this year, as compared with last year. Production of crude oil similarly was up 1.4 percent in June and 2.3 percent for the first six months. Imports of refined products were off 10.1 percent in June but were up 3.3 percent for the first half of this year. Crude oil imports were down 19 percent in June but were off only 0.4 percent for the first six months.

GEOLOGISTS... GEOPHYSICISTS

You are invited to write for GSI's new Facilities and Services Brochure



this 12-page brochure briefly describes GSI's facilities for:

- *Refraction Surveys*
- *Gravity-Magnetics*
- *Data Processing*
- *Offshore Surveys*
  - Single Ship
  - Seismic Underwater Explorer
  - Underwater Gravity
- *Theoretical and Applied Research*

GEOPHYSICAL SERVICE INC.
A TEXAS INSTRUMENTS COMPANY
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Drilling activity improves in June

DRILLING ACTIVITY increased sharply in June, with improvements in most categories.

With one less day to drill, U.S. operators completed 204 more new wells in June than in May (3,744 vs. 3,540)—for an average of 125 wells per day, up 12.6 percent over the May average of 111 per day. However, the total was down 250 wells, or 6.3 percent from the 133 wells per day completed during June 1960.

Footage drilled averaged 533,300 feet per day in June, up 6.7 percent from the 483,900 feet per day drilled during May—and less than 2 percent under the June 1960 average of 543,000 feet per day.

Operating rigs totaled 3,477 on June 30, up 147 rigs or 4.4 percent over the May 31 total—but down 2.2 percent from the 3,554 rigs operating at June's end, 1960.

Interesting to note is the sharp increase in gas well completions as contrasted with a steady decrease in oil wells drilled. During the first six months of this year, 2,341 gas wells were completed, up 20.3 percent over the same 1960 period, while oil well completions dropped 7.7 percent, to 10,100.

The same general trend is indicated in Texas. For the period January 1 through July 15, operators completed 5,019 oil wells, down 382 wells or 7.6 percent from the same 1960 period, while gas well completions jumped 564 wells or 55.3 percent, to 1,612 wells.

U.S. Drilling Activity in June and First Six Months, 1961

STATE or DISTRICT	TOTAL NEW WELLS COMPLETED									WILDCATS COMPLETED						†Active Rigs End of Month
	June							January-June		June					Jan.-June Total	
	Oil	Dist.	Gas	Dry	Service	Total Wells	Total Footage	Total Wells	Total Footage	Oil	Dist.	Gas	Dry	Total Wells		
Alabama	12	....	....	1	....	13	151,902	29	321,237	....	....	....	1	1	5	4
Alaska	4	....	....	1	....	5	47,096	21	224,181	....	....	1	1	2	4	11
Arizona	....	....	1	1	....	2	2,589	10	18,901	....	....	....	1	1	6	2
Arkansas	5	....	3	25	....	33	122,139	243	906,711	....	....	....	8	8	46	32
California	88	....	8	48	3	147	752,535	813	3,618,066	1	....	....	24	25	131	133
Colorado	3	....	10	30	....	43	212,370	261	1,260,146	1	....	1	21	23	140	50
Illinois	56	....	4	69	....	129	301,100	759	1,684,509	1	....	1	31	33	203	214
Indiana	9	....	....	48	....	57	78,035	357	551,626	....	....	....	22	22	100	75
Kansas	150	....	21	173	18	362	1,296,675	2,289	8,191,961	7	....	2	47	56	346	204
Kentucky	66	....	21	85	....	172	141,741	1,068	794,474	1	....	....	2	3	27	152
Louisiana	162	16	34	149	....	361	2,580,277	1,737	13,319,140	2	....	1	52	55	244	336
North	71	1	22	78	....	172	580,367	670	2,257,158	1	....	1	28	30	111	73
South	91	15	12	71	....	189	1,999,910	1,067	11,061,982	1	....	....	24	25	133	263
*Gulf of Mexico	32	4	5	18	....	59	635,922	263	2,725,960	....	....	....	10	10	23	59
Michigan	12	....	3	41	....	56	176,207	314	1,038,960	....	....	....	23	23	121	106
Mississippi	16	3	2	26	....	47	444,263	257	2,571,564	1	....	....	16	17	73	58
Missouri	....	....	....	2	....	2	3,209	5	8,354	....	....	....	....	....	....	3
Montana	14	....	....	20	....	34	168,115	206	1,103,073	....	....	....	18	18	91	41
Nebraska	33	....	1	61	....	95	414,335	506	2,282,684	2	....	....	46	48	228	25
New Mexico	54	....	9	21	6	90	470,712	821	4,234,415	3	....	1	10	14	121	123
Southeast	43	....	2	17	6	68	370,509	506	2,679,528	1	....	1	8	10	97	74
Northwest	11	....	7	4	....	22	100,203	315	1,554,887	2	....	....	2	4	24	49
New York	....	....	20	5	10	35	75,500	175	295,125	....	....	....	....	....	....	25
North Dakota	15	....	....	16	....	31	182,877	117	701,566	2	....	....	5	7	27	17
Ohio	54	....	13	29	1	97	245,718	464	1,157,842	1	....	....	4	5	24	115
Oklahoma	225	6	32	124	30	417	1,426,976	2,322	8,630,516	9	1	3	26	39	204	598
Pennsylvania	20	....	14	3	11	48	119,340	271	736,555	....	....	....	2	2	18	76
South Dakota	....	....	....	....	....	....	....	3	14,681	....	....	....	....	....	3	1
Tennessee	....	....	....	9	....	9	6,542	44	27,118	....	....	....	5	5	19	12
Texas	705	5	129	442	28	1,309	5,953,200	7,070	31,995,285	22	1	10	237	270	1,490	858
District—																
1: South Central	52	....	2	37	....	91	205,159	402	1,129,679	1	....	1	22	24	133	32
2: Middle Gulf	28	....	18	39	....	85	551,491	394	2,675,876	1	....	3	22	26	129	70
3: Upper Gulf	45	4	15	29	....	93	581,676	597	4,009,418	4	1	1	19	25	147	86
*Gulf of Mexico	....	....	....	....	....	....	....	4	41,134	....	....	....	....	....	4	4
4: Lower Gulf-S.W.	34	....	20	44	....	98	579,010	681	3,576,507	1	....	1	34	36	162	115
5: East Central	10	....	5	23	....	38	216,433	124	763,993	1	....	....	16	17	67	22
6: Northeast	71	1	6	39	....	117	615,131	452	2,348,344	2	....	....	18	20	70	44
7-B: North Central	77	....	12	64	1	154	460,633	938	2,832,119	1	....	1	34	36	272	72
7-C: West Central	30	....	6	20	....	56	277,362	323	1,449,254	2	....	2	18	22	118	60
8: West	177	....	13	64	15	269	1,457,932	1,362	7,470,836	6	....	....	37	43	215	168
9: North	139	....	8	72	11	230	618,991	1,222	3,171,563	3	....	1	16	20	145	120
10: Panhandle	42	....	24	11	1	78	389,382	575	2,567,696	....	....	....	1	1	32	69
Utah	6	....	4	10	....	20	119,759	119	709,469	....	....	2	8	10	48	30
Washington	....	....	....	2	....	2	9,132	10	42,620	....	....	....	2	2	8	1
West Virginia	15	....	35	17	....	67	156,927	486	1,213,833	....	....	....	....	....	....	101
Wyoming	25	....	5	27	....	57	290,265	416	2,216,808	....	....	1	17	18	139	69
Others	....	....	....	4	....	4	17,081	20	108,604	....	....	....	1	1	12	5
Total U.S., June, 1961	1,749	30	369	1,489	107	3,744	15,966,617	21,213	89,980,024	53	2	23	630	708	3,878	3,477
May, 1961	1,676	46	415	1,310	93	3,540	15,026,413	.....	.....	40	1	28	580	649	....	3,330
June, 1960	1,891	62	362	1,595	114	4,024	16,311,217	22,706	95,255,266	38	6	18	713	775	4,502	3,554
Western Canada June, 1961	99	....	27	41	....	167	822,345	1,000	5,636,114	....	....	....	....	....	....	170
May, 1961	83	....	13	27	1	124	622,068	.....	.....	....	....	....	....	....	....	138
June, 1960	126	....	37	59	....	222	1,056,458	1,175	6,454,050	....	....	....	....	....	....	169

* Gulf of Mexico wells are included in their respective district totals. † Includes wells rigging up, drilling, and temporarily shut-down.

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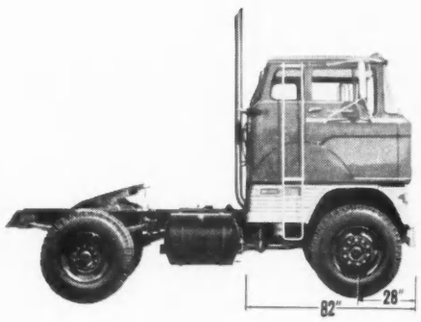
Our new folder, "Employee Profit Sharing Studies", gives full facts on how to get started on pension and profit sharing activities. Write our Trust Department for your free copy.

THE NEWEST REASON TO MAKE YOUR NEXT TRACTOR A FORD:

ALL-NEW FORD H-SERIES GAS OR DIESEL

FORD DIVISION, *Ford Motor Company*

Ford H-Series tractors offer a choice of five Super Duty V-8's or four proven Cummins Diesels for maximum performance, economy and durability! Over 500 engine-transmission-axle combinations provide "job-fitting" economy on any run.



New Ford H-Series tractors have a short 28-in. BA for hauling maximum legal loads in most "bridge formula" states. And their compact 82-in. BBC dimension accommodates longer high-cube trailers. For greater payloads within their 76,800-lb. maximum GCW range, strong lightweight components are used wherever consistent with maximum durability. Extra-hi-tensile steel frames, fiberglass cab skirts, aluminum steering gear housing, and optional aluminum disc wheels, transmission cases and fuel tanks are typical examples of Ford's weight-saving design.

Ford H-Series models are quality-built to the most exacting standards in the industry. They're the only tractors with gas engines so dependable they're dealer-warranted for 100,000 miles. And maintenance-engineered design means fewer downtime delays . . . lower maintenance costs.

SEVEN MORE REASONS

WHY IT'S GOOD BUSINESS TO DO BUSINESS WITH FORD!

You save from the start with Ford's traditionally low prices, and your savings continue with low operating and maintenance costs. These facts are documented by certified test reports from America's foremost independent automotive research firm. Ask to see these reports. They're on file at your Ford Dealer's.

In addition to these dollar-and-cents savings, the following bonus benefits are yours with Ford Trucks:

1. **Rigid quality controls** give you the strongest safeguard of truck reliability ever. Modern, *exclusive-truck* manufacturing facilities, with emphasis on quality every step of the way, are designed to give you a Ford Truck that is as free from defects as a truck can be. Tangible results of these high standards are Ford's new warranties.

2. **Exclusive 100,000-mile warranty** (or 24 months) on 401-, 477- and 534-cu. in. Super Duty V-8's is the most liberal in the industry. Each major engine part (including block, heads, crankshaft, valves, pistons, rings), when engine is used in normal service, is warranted by your dealer against defects in material or workmanship for 100,000 miles or 24 months, whichever comes first. The warranty covers full cost of replacement parts . . . full labor costs for first year or 50,000 miles, sliding percentage scale thereafter.

3. **12,000-mile warranty** (or 12 months) on all 1961 Ford Trucks of every size is further evidence of the confidence Ford has in its quality controls. Each part, except tires and tubes, is now warranted by your dealer against defects in material or workmanship for 12 months or 12,000 miles, whichever comes first. The warranty does not apply, of course, to normal maintenance service or to the replacement in normal maintenance of parts such as filters, spark plugs and ignition points.

4. **Special fleet financing** can be arranged by your Ford Dealer. It's available for owners of two or more trucks, and provides the opportunity to precisely tailor payments to your income patterns or depreciation schedules. This fleet-fitted financing offers substantial savings and frees your working capital.

5. **Sales engineers and service specialists** in 36 district offices are on call to solve special truck problems. Working with both dealers and customers, these experienced truck men represent another extra step Ford takes to provide your continued satisfaction.

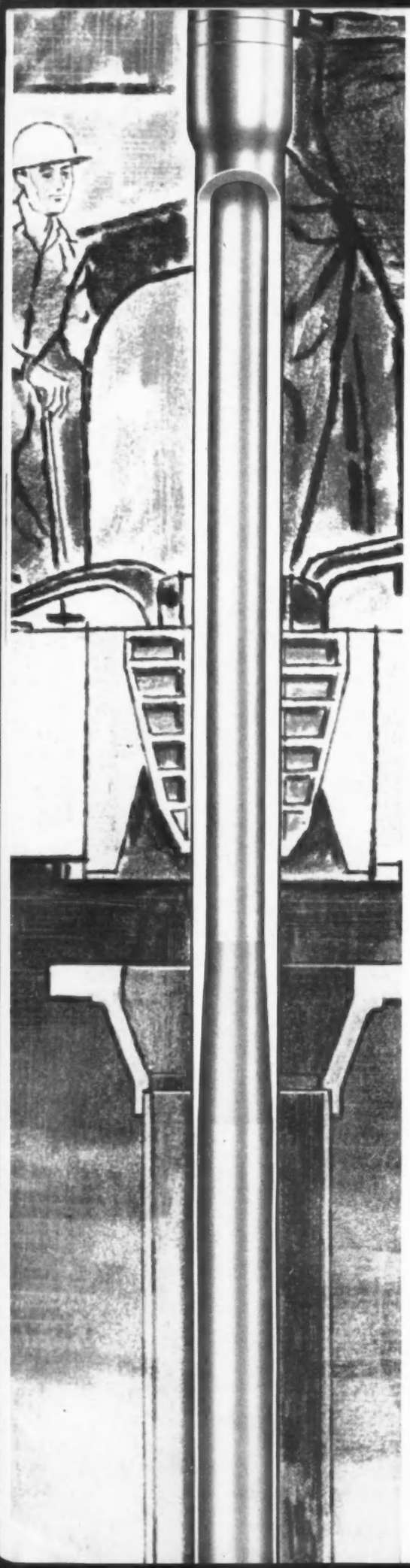
6. **Replacement parts depots** at 26 strategic locations across the country quickly supply needed parts from ample stocks. Ford's entire supply system is geared to give you faster service and reduce costly downtime . . . *wherever* you are.

7. **6,800 Ford Dealers,** including 280 specialized Heavy Duty truck dealers, can keep your trucks ready to go wherever they go. From coast to coast, fast Ford service—gas *and* Diesel—is always close at hand.

From Super Economy pickups to Diesel-powered tractors, you can now fill every truck need up to 76,800 pounds GCW with a modern, money-saving Ford Truck.

QUALITY-BUILT...MAINTENANCE-ENGINEERED

FORD TRUCKS COST LESS



PITTSBURGH STEEL REPORTS ON...

DUAL WEIGHT DRILL PIPE

SUCCESS IN FIELD TEST

In West Texas, South Louisiana, Oklahoma and out on the West Coast, Pittsburgh Steel Company's new Dual Weight Drill Pipe is proving itself the way drillers best understand—by performance under actual field conditions.

Dual Weight is a completely new type of drill pipe developed and produced exclusively by the manufacturer of "Pittsburgh Seamless."

It provides drillers an integral combination of strength and light weight never before available in popular API grades and sizes of drill pipe.

Drilled footage on four strings of Dual Weight now stands at better than 100,000 feet—every inch of it under normal rotary drilling practices.

Results? Excellent—better than expected in some cases.

Field tests are continuing. Additional strings are being placed in service on drilling operations specifically selected to prove out Dual Weight's advantages and performance under the widest possible range of drilling conditions.

But, so far, here's what experience shows Dual Weight does:

- Cuts drill string weight.
- Increases rig depth capacity.
- Increases slip area strength up to 20 percent.
- Boosts hydraulic performance.
- Effects lower maintenance costs and longer service life on rig equipment.
- Cuts transportation costs.
- Increases drilling rates and speeds up round-trips.

• **What is Dual Weight?**—First of all, it's one of the most important developments in rotary drilling in many years. It's an entirely different type of drill pipe design—although it looks the same as other drill pipe. The difference is in the ID.

Look at the cutaway sketch at the left of this page. It shows Dual Weight's design features.

Notice the box end. Below the tool joint and upset, it has at least four feet (but not more than six feet) of heavy wall steel in the critical slip area. Then, a gradual, uniform internal taper makes transition to a light wall body that extends the remainder of the joint's length.

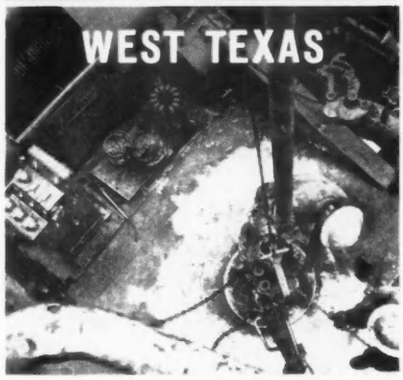
Some drillers refer to the heavy wall at the box end as a "long upset"—a good description, but inaccurate. The heavy wall is produced

by a patented process that bears no resemblance to upsetting.

Drillers can benefit two ways with Dual Weight.

If it's a lower hook load they want, then thin wall Dual Weight meets the need. It combines the strength of standard pipe in the slip area, and the weight saving of lighter weight pipe in the body.

Or, if extra strength and safety—rather than lower weight—are required, Dual Weight again is the answer. In this version, it has a standard wall body and an extra heavy box end with a safety factor



near or equal to the safety of the body.

• **Strength?**—Either way, Dual Weight has it—in the slip area where it's needed to resist the notching, crushing, crimping, stretching and bending forces it is subjected to.

Light weight? Its thinner wall body eliminates pounds per foot over 85 percent of the length of a 30-foot joint.

For example, 4½-inch Dual Weight with a .337/.254-inch wall weighs 16.60 lb./ft. for 15 percent of its length (the box end) and 13.25 lb./ft. for 85 percent of its length (the body).

And don't overlook hydraulic performance. The larger ID resulting from Dual Weight's thinner body wall lets pumps push more mud at lower pressures. There's more energy applied at the bit. Penetration rates are higher and returns are better.

But here's a sample of how drillers themselves benefit from Dual Weight.

A Large Independent Oil & Gas Drilling Corporation—drilling shallow wells in West Texas with 6,000 feet of 4-inch (.330/.254-inch wall) Grade E Dual Weight.

A Drilling Superintendent—"I believe Dual Weight is the only thing for a little rig. Its lighter weight means less wear and tear on the rig and equipment. And when you move as often as we do, there's quite a saving on trucking charges. Any time we can get away from handling weight, we're better off."

A Veteran Tool Pusher—"We save trip time because we can come out of the hole faster. With less weight we get more rpm's. We save fuel, too, because our engine isn't working as hard."

• A major oil company, drilling deep wells in Louisiana with 15,000 feet of 4½-inch, (.337/.271-inch wall) Grade E and P-95 Dual Weight.

A company drilling engineer said: "We're looking for higher velocities and larger volumes of fluid at equal pump pressures from Dual Weight. We know we're getting better hydraulics—moving more fluid.

"In deep drilling with high mud weights, you get better penetration with increased bit hydraulic horsepower. We calculate we're getting a 25 percent increase in BHP."

Interested in more detailed information? Write for literature, or contact a Pittsburgh Steel district sales office or one of the independent distributors listed below.

Distributor Home Offices

Atlas Bradford Company Houston, Texas	**Iverson Supply Company** Dallas 1, Texas	**The Producers Supply & Tool Co.** Fort Worth 2, Texas
Bennett Supply Company Midland, Texas	**Longhorn Supply Co., Inc.** Houston 14, Texas	**Sandy Supply Company** Wooster, Ohio
Buckeye Supply Company Zanesville, Ohio	**Lucey Export Corporation** New York 7, New York	**Southwest Supply Company** Pittsburgh, Pennsylvania
C. W. Cotton Supply Company Tulsa 5, Oklahoma	**Lucey Products Corporation** Tulsa 19, Oklahoma	**The Straker Supply Company** Jackson, Michigan
Franklin Supply Company Denver 10, Colorado	**McJunkin Corporation** Charleston 22, West Virginia	**Superior Iron Works & Supply Co.** Shreveport, Louisiana
Houston Oil Field Material Co. Houston, Texas	**Midland Supply Company** Wichita 7, Kansas	**Tex-Tube, Inc.** Houston 7, Texas
Industrial Supply Company Wichita Falls, Texas	**Mountain Iron & Supply Co.** Wichita 2, Kansas	**Western Supply Company** Tulsa 1, Oklahoma

Pittsburgh Steel Company

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Atlanta	Cleveland	Dayton	Los Angeles	Pittsburgh
Chicago	Dallas	Detroit	New York	Tulsa
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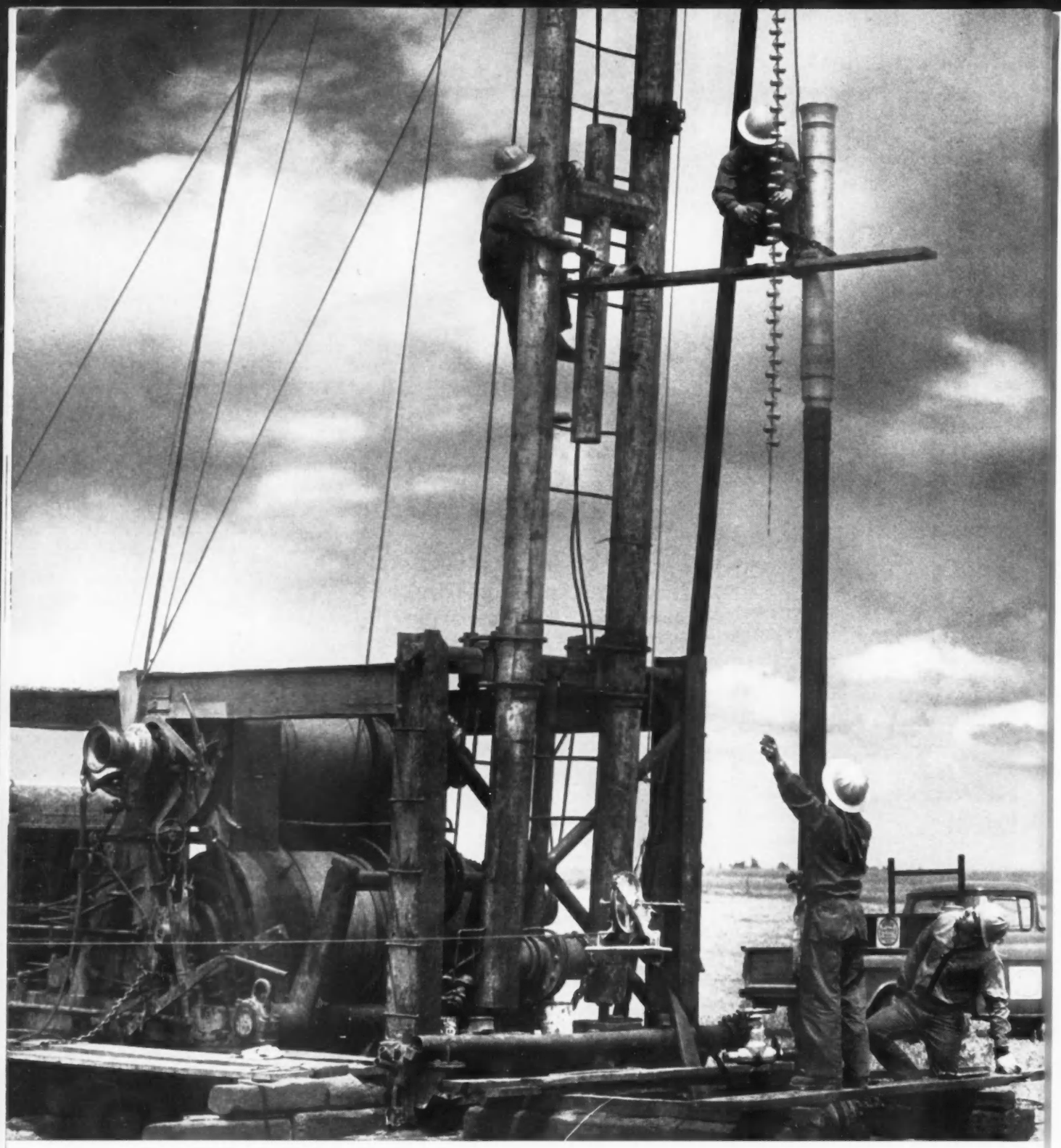
Steel



Servicing the Herron No. 1. This servicing unit, owned by McKaig Well Servicing Company, Crescent, Okla., was photographed as preparations were being made to reperforate the hole at the Herron No. 1, located near Hunter, Okla. The unit was rigged with 7,000 ft of Bethlehem 9/16-in. 6 x 7 sand line with plastic core, and 8,000 ft of Bethlehem 3/4-in. 6 x 19 drilling line with fiber core. Bethlehem Wire Rope, because of its ruggedness and ease of handling, is ideal rope for servicing units.

There's a distributor of Bethlehem Rope near you, supplied by our nationwide network of wire rope mill depots.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
Export Sales: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Steel

for Strength
... Economy
... Versatility

BETHLEHEM WIRE ROPE
BETHLEHEM STEEL

Better Production Tools Through Research

OTIS Equipment NEWS

Volume III, Number 3 **Otis Engineering Corporation • Dallas** *Production Equipment and Services*

Now...An Otis Flow Line Safety Valve And Pilot For Only $295.00

Proven Otis Safety Valve Design Costs Less Than Many "Substitute" Safety Devices

DALLAS—An all new flow line safety valve employing the time-proven Otis Safety Valve design is now available for installation on wells requiring shut-in protection in the event of flow line breakage. The new valve, designated the Type K Otis Flow Line Safety Valve, may be purchased in the popular 2-inch, 3,000 p.s.i. screw-end size complete with a new Type BE Otis Low Limit Pilot for $295. The Type K Valve is also available with flange-end connections at slightly higher cost. The valve and pilot are designed to automatically shut in a well when flow line pressure drops below the pre-set limit of the pilot. The pressure drop may be due to a break in the flow line itself or the malfunction of auxiliary equipment downstream of the valve. The new Type K Valve and BE Pilot combination offers oil and gas producers effective Otis Safety Valve protection at a new low price — a price which in many cases is lower than that of substitute safety devices such as diaphragm - operated motor valves, etc.

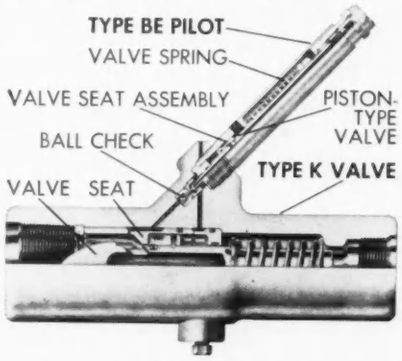
PRICES — TYPE K VALVE AND BE PILOT COMBINATION

Size — Type End	Working Pressure Rating (p.s.i.)	Price
2" — Screw	3,000	$295.00
2" — Screw	5,000	335.00
2" — Flange	3,000	345.00
2" — Flange	5,000	385.00

Note: Be sure to specify pressure range for pilot.

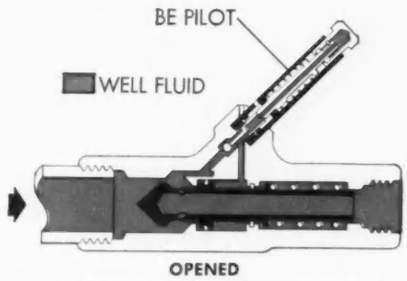
Valve Operating Principles

The Type K Otis Flow Line Safety Valve is a pilot-controlled pressure-operated safety valve designed to automatically shut in a well in the event of abnormal changes in pressure on the flow line or when control pressure from an external source rises above or falls below that for which the pilot is set. On installations where pressure from within the flow line is to serve as the pilot control medium (see schematic drawings), flow line pressure is equalized across the valve and the pilot to permit a spring in the safety valve to hold the valve piston off seat. When pressure within the flow line falls below the set pressure of the pilot, the pilot is designed to exhaust the pressure from behind the valve piston. This action serves to create a differential across the valve and allow flow to close the valve instantaneously. The valve is designed to be reopened by screwing in the nut on the pilot which acts to force the ball check in the pilot boss off seat to equalize pressure across the valve. When installed with the Type BE pilot, the valve serves to provide low-pressure protection. If both high and low pressure protection is desired, the Type E Otis Pilot is recommended. For remote protection, the Type N & P Otis Pilot combination is available.



Pilot Operating Principles

The Type BE Low Limit Pilot is a spring-loaded, pressure-actuated control pilot designed to actuate the Type K Otis Flow Line Safety Valve in the event of a drop in flow line pressure below the pre-set limit of the pilot. The pilot consists of a body, a piston-type valve and valve seat, and a valve spring. When installed on a Type K Valve, a port in the safety valve body, the pilot seat assembly, and the pilot valve serves to admit flow line pressure to the pilot. This pressure acts to hold the pilot valve on seat against the force of the valve spring. In the event of a pressure drop across the valve and pilot, the spring within the pilot is designed to force the pilot valve off seat, permitting the pilot seat assembly to move up so that the ball check in the safety valve boss can seat. This action serves to exhaust pressure within the valve, create a pressure differential across the valve and permit the valve to close.



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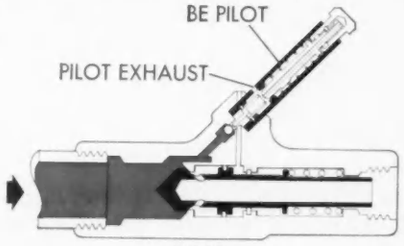

CLOSED

Valve and Pilot Design Advantages

Both the Type K Otis Flow Line Safety Valve and the Type BE Otis Low Limit Pilot are of the simplest design and construction to provide reliable and positive operation. The flow path through the Type K Otis Flow Line Safety Valve has been engineered to permit high flow volumes with a minimum pressure drop. The valve was also designed with no small ports or natural body traps to avoid areas in which hydrates and/or paraffin might accumulate to foul the valve's operation. Both the valve and pilot are so designed as to permit each to be used with other Otis Safety Equipment.

Otis Surface Safety Valves and Pilots have long been recognized as the very finest. Otis Safety Valve Specialists have earned the same enviable reputation. Whatever your well safety valve requirements, Otis can be of help. For more information on Otis Safety Equipment, or for help with a specific safety valve installation problem, call the Otis office nearest you, or write Otis, Dept. 3-E, P.O. Box 35206, Dallas 35, Texas. You'll find experienced Otis Safety Valve Specialists ready to help you — anxious to serve you . . . with the widest variety of field-proven safety valves and pilots available today.

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OTIS

Engineering OTIS Corporation

General Offices:

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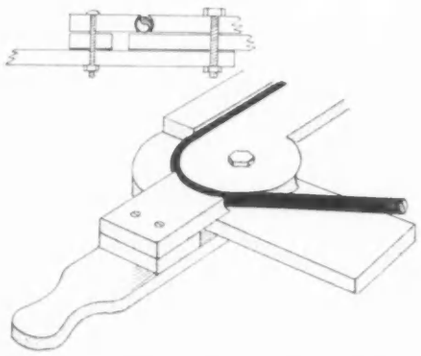
For more data on advertised products, use cards, last page.

Practical Operating Hints

These **How-To-Do-It** Ideas Can Save You Money



Copper Tubing Bender Made Easily From Hardwood

It's easy to make a copper tubing bender, which can also handle small diameter pipe, from hardwood and a few bolts. The bender will not flatten tubing or scratch it.

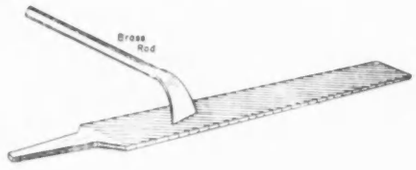
The bender has three main parts: the back-up ring, the handle and the dog that pulls the tubing around the back-up ring. The back-up ring can be cut on an ordinary wood lathe. Its radius should be that of the bending radius of the copper tubing and the circular groove in the outer edge should fit the tubing.

The handle bolts onto and pivots from the center of the back-up ring. Attached to it is the dog, which actually makes the bend. This dog must be grooved to fit the pipe tightly as the bend is being made. Its friction with the tubing prevents kinking by causing the outer edge of the tubing to stretch. Note that there is a slot alongside the back-up ring which holds the straight portion of the tubing during the bend.

To make a bend, simply insert the copper tubing into the slot and turn the handle until the proper number of degrees have been reached.

Tool Made From Brass Rod Is Used as File Cleaner

Chips that cannot be removed with a file card can be dislodged with this tool—made by flattening the end of a brass rod, then bending it to a curve. Soft brass will not dull the file.



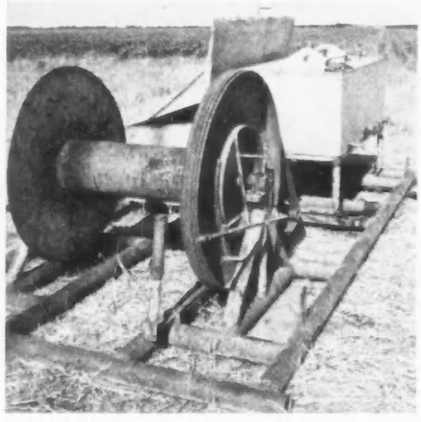
Let Leg of Derrick Serve As Stand Pipe to Carry Mud

In drilling shallow holes, a savings can be made in piping by using the leg of the derrick as a stand pipe to carry the drilling mud half way up the derrick. A connection for the hose from the mud pump is made at the base of the derrick and then the connection for the rotary hose is made in the middle of the derrick leg.

By using this arrangement, the stand pipe becomes an integral part of the derrick and cuts down on the amount of material that must be moved between locations. When it comes time to rig up, the derrick is raised, the rotary hooked up and drilling operations can commence.

Simple Heat Exchanger Helps Break Emulsion

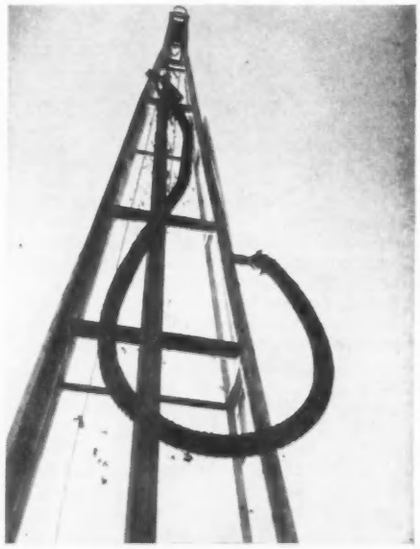
A simple heat exchanger was installed on this separator input line to provide additional heat for a tight emulsion. A "hot" water well is produced through the shell side of the heat exchanger as the heat source. The heat provided at the separator, plus the normal hot water section in the gun barrel, allows proper separation of the oil-water emulsion. Before the heat exchanger was installed, proper separation was impossible.



Mounted Electric Motor Spools Drilling Lines

Where it is necessary to make many moves in shallow drilling and workover operations, a combination wireline spool and lube oil box can be mounted on the same skid.

In order to make it easy to spool the drilling cable, an electric motor can be mounted close to the spool and V belts stretched over the band on the spool. A brake is then rigged up to hold a strain on the wire rope as it is spooled up at the rig.



Give You
straighter smoother flow of drilling fluid
with minimum pump pressure
and
maximum jetting action

Plus
field-proven threaded flow nozzles for easy installation

Smith threaded flow nozzle sectioned to illustrate o-ring seal and general construction.

Smith TOOL CO.
A Division of SMITH INDUSTRIES International Inc.
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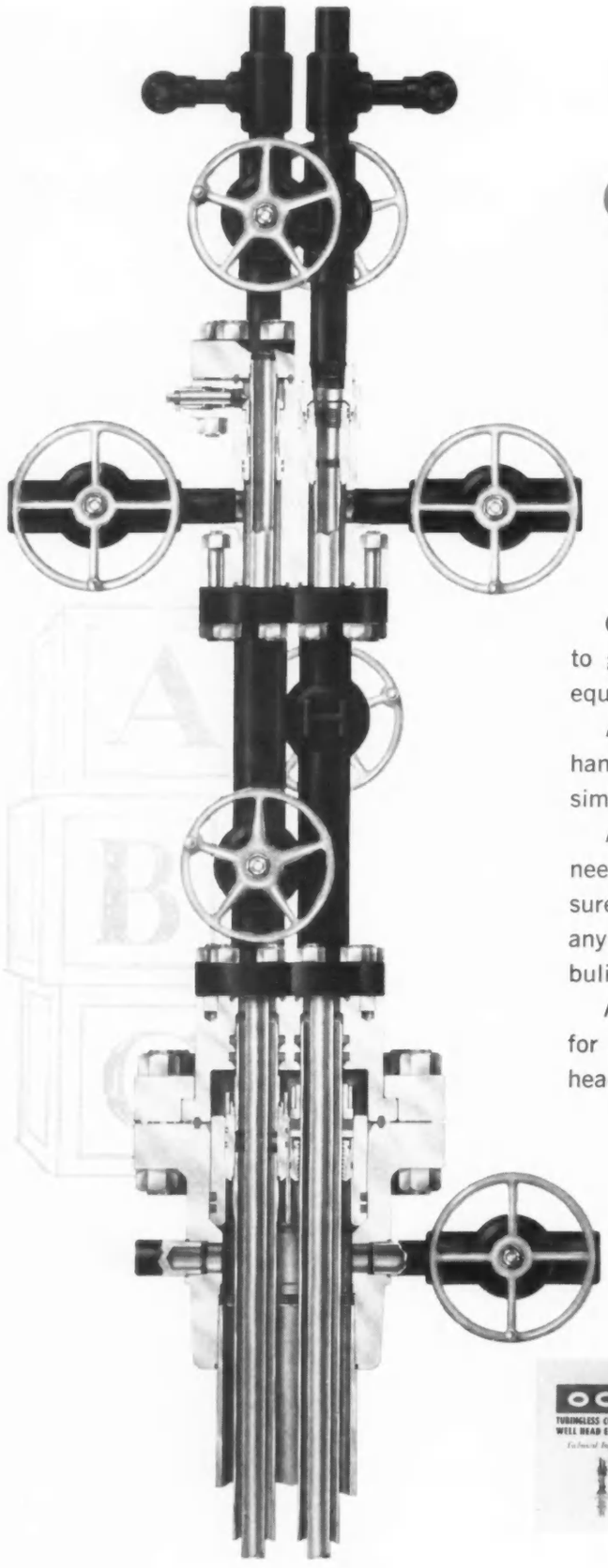

Tubingless Completions are simpler with O·C·T equipment

O·C·T tubingless completion equipment is designed to give you simplicity and flexibility that simplify your equipment problems.

A complete line of interchangeable slip and threaded hangers lets you suspend from one to eight tubing strings, simply by changing hangers.

A variety of casing heads for these hangers meets your needs for single or multiple completions, at working pressures up to 10,000 psi. Master Bushings allow assembling any desired multiple completion and permit running turbulizers, centralizers or other related downhole equipment.

A new type M (for macaroni) tubing head is supplied for hanging 1½-inch and smaller tubing strings. These heads can be furnished with either flanged or threaded connections on top and bottom. Crescent flanges, tri-flanges, and quadri-flanges are available.

If you want to use an economical tubingless completion on your next well, talk with your nearby O·C·T representative. He can show you the latest in tubingless completion equipment.

Write for the helpful free booklet, "O·C·T Tubingless Completion Well Head Equipment," which discusses requirements for tubingless completion equipment.

where progress is a daily practice

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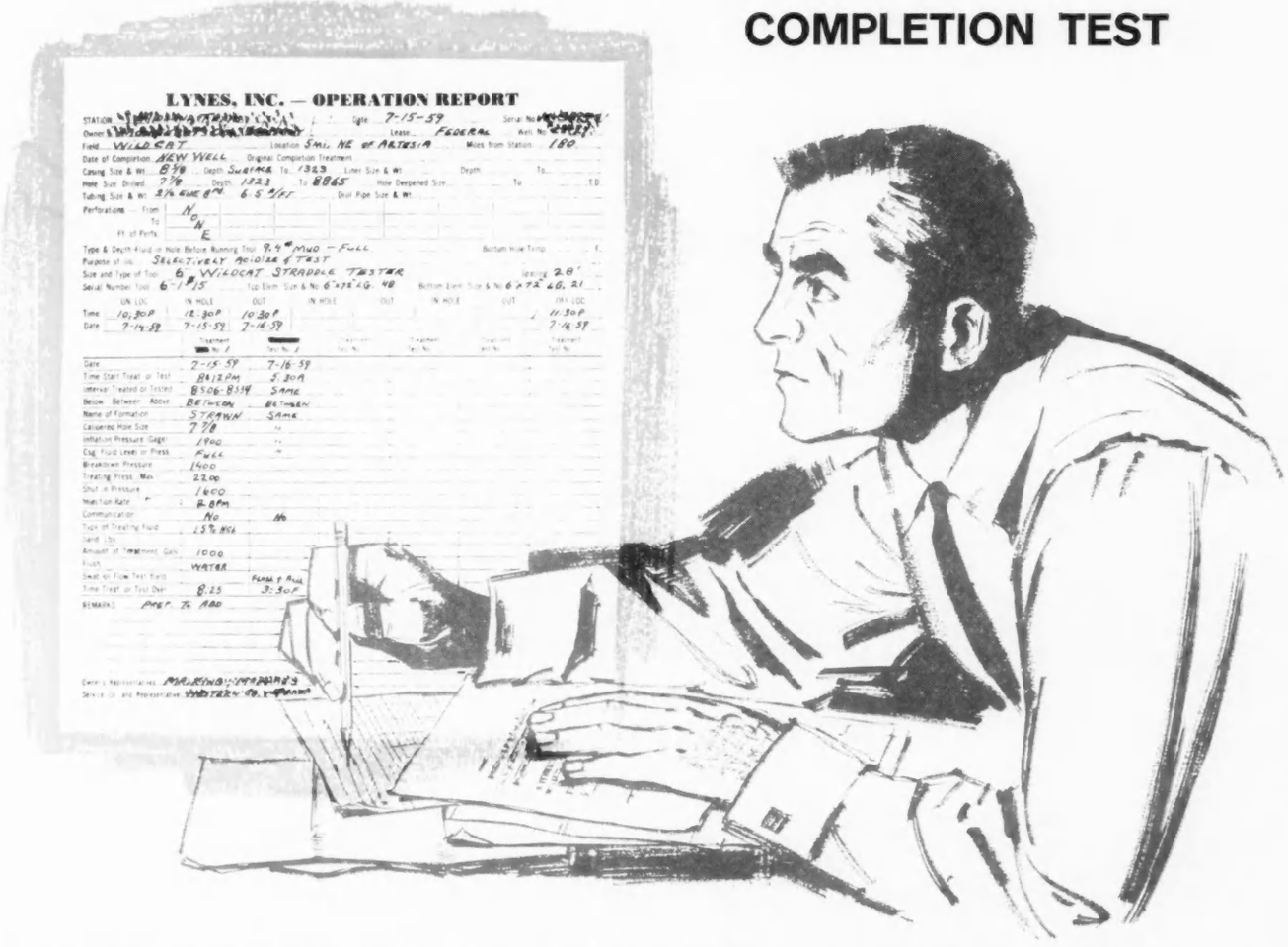
MINIMUM OF $8000 ON DRY HOLE COMPLETION TEST



LYNES Wildcat Open-Hole Test Service takes the gamble out of completion of questionable 8800-ft. New Mexico wildcat. Drill stem tests on a wildcat in the Artesia, New Mexico, area had been inconclusive so the operator was faced with the choice of setting casing, perforating, treating the formation and recovering the casing if the hole was a duster or of abandoning the well without additional testing at the risk of passing by a producer OR HE HAD THE CHOICE OF RUNNING A LYNES OPEN HOLE INFLATABLE WILDCAT TEST STRADDLE PACKER THAT WOULD ALLOW HIM TO MAKE POSITIVE WELL TESTS AT A VERY LOW COST.

Choosing the LYNES Test Service, the operator saved $8000 by eliminating normal completion and abandoning expense to conclusively prove the well dry—savings up to $20,000 have been reported. Had the well proved a producer, he would have saved a well that he might otherwise have abandoned rather than risk the cost of completing a dry hole.

The swab test through a LYNES Tool is more positive than a D.S.T., but the potential of the LYNES Test does not stop there. Stimulation treatment is a normal progression of this test—then further Swab Testing.

Many operators do not D.S.T. where results are expected to be questionable. They drill to T.D., then come back up hole testing all shows.

Single element tools can be opened above or below and straddle tools can be opened above, below or in between. LYNES Inflatable Tools can be reset anywhere in hole without tailpipe or formation anchor.

LYNES Inflatable Packers have endless variety of uses in testing, treating and production operations in the field. The inflatable sealing element will expand up to twice its run-in size to effectively seal in open hole or casing and will hold high differential pressures from above or below.

Ask your LYNES man to explain the many uses of LYNES packers to save you money on your well completions.

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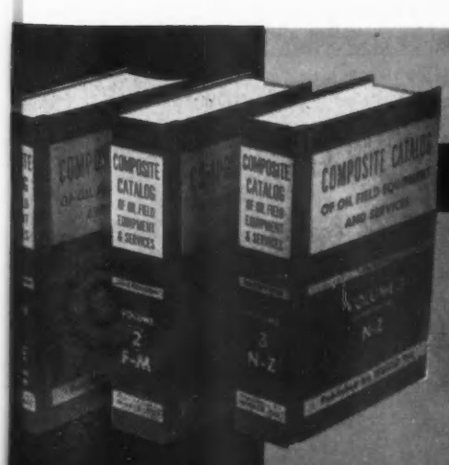

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Published by WORLD OIL

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"Every dollar in our production budget is doing a man-size job . . . take these Unibolt Valves, for instance"

The UNIBOLT WING VALVE was designed originally as an "adjustable choke" for Christmas tree service. It is performing that job with distinction everywhere.

However, production men have found so many other uses for this wing valve that it is losing its original identity and is now regarded as an excellent multi-purpose valve!

Gas meter runs are one good example of this valve's versatility. It is equally popular on oil gathering manifolds, waterflood injection manifolds, heater-treaters, and a wide range of special valve applications. The one-inch opening in the UNIBOLT Valve will usually pass a far greater volume of gas than can be produced. Unlike conventional single purpose gate and plug valves, the UNIBOLT Valve offers a number of advantages: Conversion to positive choke or Pressurematic Valve, completely salvageable, easily renewable parts, and selective trims.

Make every dollar in your production equipment budget do a man-size job, too! UNIBOLT Valves, Fittings, and Couplings are made for you with that in mind.

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P. O. Box 1184, Houston, Texas

OLD HAND AT TUBINGLESS COMPLETIONS

First to recognize the economic importance of "tubingless" completion techniques, Texas Iron Works pioneered the design and development of small diameter tools to provide maximum efficiency at minimum cost.

In design, in materials and in precision manufacture, T-I-W Tubingless Completion Tools represent the finest that modern science has developed . . . the result of more than 40 years of continuous experience in providing quality production equipment.

T-I-W Tubingless Completion Tools have been thoroughly and satisfactorily field tested in numerous West Texas, South Texas and Gulf Coast area wells . . . providing an outstanding record in economical completion.

Field-trained T-I-W service engineers can provide case history details to assist you in your Tubingless Completion program.

Call, write or wire for complete details on the T-I-W line of Tubingless Completion tools, immediately available anytime . . . anywhere.

1—T-I-W Type AH Packer, with Hold-Down Slips
2—T-I-W Type AH Packer, less Hold-Down Slips
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4—T-I-W Tubing Centralizer
5—T-I-W Double Box Tubing Landing Collar
6—T-I-W Male Type Drillable Tubing Guide Shoe
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The only wiper plugs on the market that will not rotate if it becomes necessary to drill out.

Manufacturers of T.I.W Portable Rigs . . . T.I.W. Safety Joints . . . T.I.W. Rotary and Casing Slips . . . T.I.W. Quick Stem Safety Valves . . . T.I.W. Packers for every purpose . . . T.I.W. Pump Chambers . . . T.I.W. Mudmixers . . . and many other oil field tools.

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Don't offer me a "Pig-in-a-Poke bargain."
I want equipment that does not leave
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Can you FORECAST sleeve success

The cylinder sleeves or liners shown here appear to be identical. Actually they are vastly different. One will last far longer than the other.

If you picked the one on the left to last longer, you're correct. It meets the hardness requirements that Mack engineers find necessary for maximum life. This means the sleeve is hard enough to provide many thousands of miles of trouble-free life . . . that piston ring and piston scuffing will be minimized. This sleeve is a genuine Mack part.

But the "will-fit" sleeve on the right could not even be measured on the same hardness scale as the Mack liner. It is too soft. Because it is softer . . . and because it is not impregnated with a surface lubricant as is the Mack sleeve . . . this liner will wear more rapidly. It is much more prone to ring and piston scuffing and premature failure. And the "will-fit" sleeve's life expectancy is naturally short.

Unless you can afford the expense of extensive laboratory and field tests, it's impossible to forecast the success or failure of a replacement part. You are far better off specifying genuine Mack parts. Only then can you be sure of preserving the quality you invested in originally. Sometimes you are actually improving performance since Mack is consistently improving its parts—original and replacement alike.

When it comes to service, you should make the same comparison. Mack-trained mechanics can make a big difference, too. Mack Trucks, Inc., Plainfield, New Jersey. Mack Trucks of Canada, Ltd., Toronto, Ontario.

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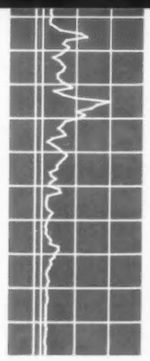

Two men...the inspiration for six thousand

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BENDIX AE INERTIA STARTER

More easily mounted and in more positions • Can be installed in ten minutes without the use of any special tools • Completely self contained . . . no "extras" to buy.

Requires **NO CABLES, NO PUMPS, NO PLUMBING.**

The Bendix* AE Inertia Starter is rugged and dependable under difficult operating and climatic conditions. It is especially suited for use in remote areas where battery maintenance is a problem, or where there is a fire hazard. For complete information, write:

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is Easy on the Rods!

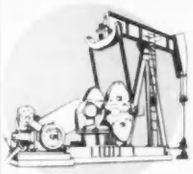
REDUCES ROD LOAD UP TO 10%

IT'S THE POLISHED ROD MOTION THAT DOES IT!

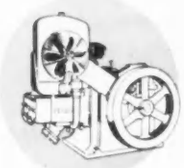
- **SLIM HOLES**
  Where small diameter tubing limits the size of sucker rods, the lower rod stress obtained with the MARK II allows the use of longer rod strings or larger pumps.
- **DEEP HOLES**
  Extends range of sucker rod pumping to depths previously unattainable.
- **BIG VOLUME WELLS**
  Lowered peak load conserves a greater portion of the polished rod capacity for handling additional fluid.

A NEW unit with the same OLD Lufkin Ruggedness and Dependability

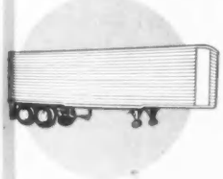
Due to the unique geometry of the MARK II, acceleration at the bottom reversal is decreased as much as 40%. This reduces peak loads up to 10% and tends to avoid shocks, resulting in longer rod life and lower servicing costs.



PUMPING UNITS



GAS ENGINES



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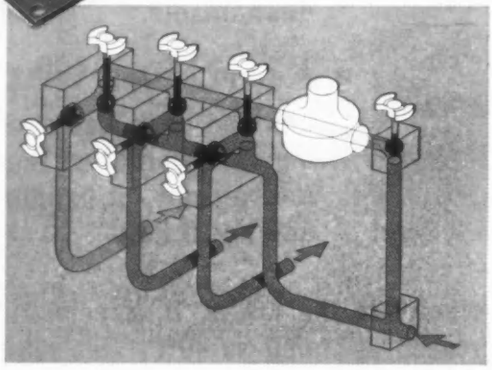
Oilmaster

HYDRAULIC PUMPING CONTROL MANIFOLD

"BUILDING BLOCKS" offer... Simplicity, Flexibility, Economy



Simplicity and Flexibility mean Economy with the new Oilmaster concept for Central Power Control Manifolds. Previously, hydraulic pumping systems required a maze of manifold plumbing to direct and control the rate of power oil flow to individual wells. Oilmaster has refined this plumbing maze to a simplified "building block" control system which is more efficient and easier to operate. This control system is built around well control stations, each having internal valves and ports for power oil distribution and control. One control station is included in the manifold for each well in the system. The manifold also includes the flow meter that allows selective metering of any well in the system. This "building block" design facilitates assembly and installation of Central Power Control Manifolds.

The block construction simplifies the control operation by permitting rapid switching to the meter header without interrupting the controlled flow of power oil to each well. Individual well control blocks are joined by flanged connecting spools which form continuous power oil passages to each block. Additional wells can be added to the manifold with minimum effort and cost... and the manifold or any component is salvable for moving to other installations.

For extra economy and flexibility the stainless steel valve seats are replaceable, and all valve parts are interchangeable with other elements of Oilmaster surface equipment. All valve stems have pressure actuated teflon packing to assure free turning. Large flow passages are provided for minimum pressure loss, and all connections are flanged with face type O-ring seals.

See your Oilmaster or distributor representative for further information or write Fluid Packed Pump, Armco Steel Corporation, 9100 S. Norwalk Blvd., Los Nietos, California for Bulletin 6103.

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ARMCO Fluid Packed Pump

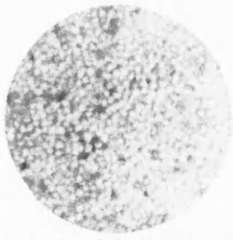
New proppant boosts well production!

REYNOLDS ALUMINUM FRAC-SHOT™

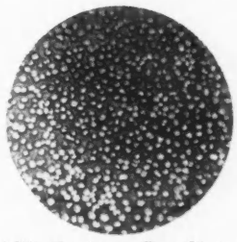
Aluminum Shot—New Propping Agent

Reynolds Frac-Shot is a new propping agent which makes well fracturing more effective, more profitable. Since its introduction, Frac-Shot has proved itself in hundreds of wells, boosting productivity many times over conventional fracturing methods.

The new propping agent is aluminum "shot"—malleable pellets of aluminum, carefully sized and processed for well servicing. It is available from all major service companies.



Standard 14/18 mesh ottawa-type sand at 10,000 ft. Note how grains crush and pack together, blocking flow.



12/16 aluminum Frac-Shot at 10,000 ft. Sparse distribution permits free flow.

Photos courtesy Pan American Petroleum Corporation and The Atlantic Refining Company.

Better Flow from Fractures

Two qualities make Frac-Shot a more effective propping agent than conventional materials: (1) It doesn't crush and "pack" the fracture, and its sparse distribution permits more flow. (2) The Frac-Shot pellets are malleable, deforming slightly under pressure to provide even better fracture support.

Where sand alone may crush and block the flow in a fracture—or be pressed into the fracture walls, Frac-Shot pellets keep fractures open and permit fluids to flow freely.

Tests Prove Frac-Shot

In Kern County, California, a well that had been previously fractured with walnut shells at about 12,150 feet was producing 21 b/d net. After treatment with approximately 3,200 lbs. of Frac-Shot at about the same depth, the well showed a steady increase until it leveled off at 182 b/d. It is expected that production will be sustained at this level.

In another recent field test at 7,050 ft. in the Wilcox formation in Texas, 4,500 lbs. of Frac-Shot was used as a "tail-in" after 13,000 lbs. of sand. The gas production in this well was increased from 130,000 c.f.d. to 700,000 c.f.d. Previous history in this field indicated that conventional fracturing techniques would have produced only 260,000 c.f.d.

Use and Cost

Frac-Shot is used primarily for "tailing-in" conventional fracturing treatments. Sand is used first, and then Frac-Shot is added to occupy 25% of the radius nearest the well bore.

Although Frac-Shot costs somewhat more than sand, the additional expense is quickly offset by the great increase in production of fractured wells. And, on very deep wells, Frac-Shot may actually cost less than an all-sand fracture, due to the great amount of sand required.

Get Full Details

Frac-Shot is available from all major service companies. For full information and free brochure on Frac-Shot, contact the people who know aluminum *and* aluminum for petroleum use—your local Reynolds office. Or write: *Reynolds Metals Company, P. O. Box 2346-CE, Richmond 18, Virginia.*

Watch Reynolds TV show "Harrigan & Son", Fridays—ABC-TV.

PRECISION CONTROL

...THE ADDED BENEFIT IN HALLIBURTON BULK CEMENTING

As unforeseeable formation conditions have become more difficult in today's deep drilling, precision cementing control has become an absolute necessity. Halliburton provides this Precision Control in operations involving cement blending, mixing and pumping.

Accurate control of slurry weight is accomplished with instruments such as the Halliburton Densometer and Densitroller. Control of handling and pumping the cement belongs to the modern Halliburton Cementing Equipment. Downhole, special Halliburton tools carry precision control through to the cementing target — formations needing protection. All of these control techniques have been pioneered by Halliburton in the performance of over three million service jobs during the past three decades.

This precision cementing capability is exercised by your Halliburton Cementer. He knows how to use the tools, machines, and materials to help you get the very best results possible from your cementing job.

Some Halliburton methods for providing Precision Cementing Control...

OF SLURRY DENSITY

POZMIX CEMENT provides a more economical light-weight slurry that gives more fill-up per sack, pumps easily, and perforates with less shattering. Natural or artificial pozzolans used in this slurry react with the free calcium hydroxide released when portland cement hydrates . . . increasing resistance to sulfate attack.

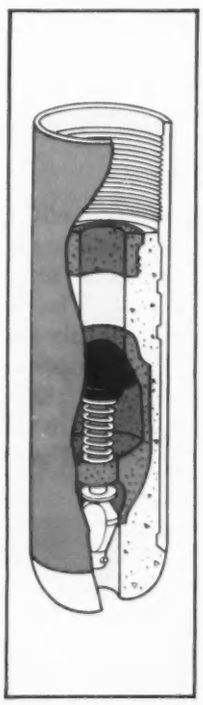
OF SETTING TIME

HALLIBURTON HA-5 improved cement accelerator reduces waiting-on-cement time in shallow wells or on surface pipe. Adding low concentrations of HA-5 to dry cement or mixing water reduces the WOC time to four to eight hours, depending on temperature, cementing composition and strength desired at the time of drilling out.

OF FLUID LOSS

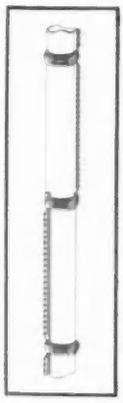
HALLIBURTON HALAD-9 controls fluid loss of cementing compositions to increase efficiency in primary and squeeze cementing. Sustained heat stability under extreme bottom-hole temperatures provides an advantage in hesitation squeeze techniques.

WITH MODERN TOOLS



AUTOMATIC FILL-UP SUPER SEAL FLOATING EQUIPMENT eliminates frequent stops for manual filling of casing — saving rig time. Carefully-calculated orifices in the fill-up attachment permit control of fluid flow into the string. An orifice sleeve attached to the Super Seal valve stem holds the valve off its seat, permitting filling.

Increasing pressure from a conventional rig pump at any time shears a pin and allows the spring-operated Super Seal back pressure valve to close and help float casing to desired hole depth. All internal parts are drillable. Halliburton Automatic Fill-Up Super Seal Float Shoes and Float Collars are available for all standard casing and tubing sizes.



HALLIBURTON ROTO WALL CLEANERS remove mud cake from the borehole wall . . . provide a better cement bond and minimize squeeze cementing jobs. This easy-to-install cleaner causes less mud cake disturbance while running casing and operates only in the zones where needed. Coiled springs inside the cleaner base protect spikes from damage while running-in and rotating to remove unwanted mud cake. Roto Wall Cleaners are available to meet all specifications — including slim hole sizes.

HALLIBURTON S-3 CENTRALIZER centers to secure uniform cementing on all sides of the casing for a better cement bond . . . even in greatly deviated hole. Clearance between the centralizer's end bands and the casing permits free rotation of the casing. The centralizer's 28-in. long heat-treated steel springs cover adequate sidewall to avoid key seats. Open spring spacing provides free fluid flow.

Call Halliburton for the Precision Control which gives you Dependable Cementing

CEMENTING SERVICES

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275 Service Centers . . . just minutes away from your well

For more data on advertised products, use cards, last page.

another
TRETOLITE SERVICE
report

Squeeze Treatment Doubles Oil and Gas Production

The treatment of nine wells on a Texas lease was simple, effective and low in cost—about $300 to $350 per well for TRET-O-LITE demulsifying chemical, pressure pumping truck, and vacuum tank truck. Most of the wells were completed through tubing, with packers set above perforations. Several were dual completions, with two strings of tubing and producing zones separated by packers.

How Tret-O-Lite Chemical Demulsifier was used*

Thirty gallons of TRET-O-LITE demulsifying chemicals were mixed with sixty barrels of lease crude (40° API). This mixture was pumped into tubing of each well, followed by enough crude to allow about 300 feet of oil-chemical mixture to stand in tubing. Each well was then shut in for 18 to 24 hours.

Pays for itself in two days

The figures in the table show how effectively the TRET-O-LITE squeeze treatment increases production in the nine wells.

The increase in production was sufficient to pay for the cost of the total squeeze job in about two days.

WELL	DEPTH	MAXIMUM INJECTION PRESSURE	PRODUCTION BEFORE SQUEEZE		PRODUCTION AFTER SQUEEZE		GAIN BBLS. /DAY
			BBLS. OIL/DAY	MCF GAS/DAY	BBLS. OIL/DAY	MCF GAS/DAY	
1	9642	4800	34	153	61	593	27
2	8381	3000	30	5	52	83	22
3	9640	3600	35	224	87	323	52
4	9625	4500	40	672	50	497	10
5	8484	3700	27	339	51	700	24
6	9652	3000	53	35	83	353	30
7	8397	5200	30	32	125	238	95
8	8408	3800	15	12	129	94	114
9	9310	3600	0	0	123	760	123
	TOTAL		264	1472	761	3641	497

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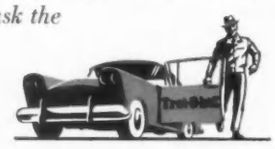

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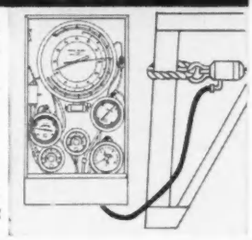

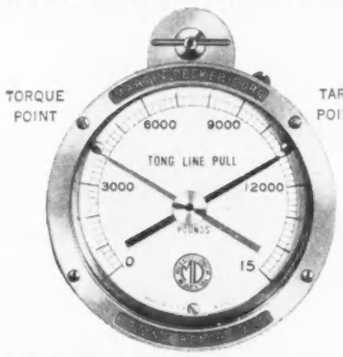

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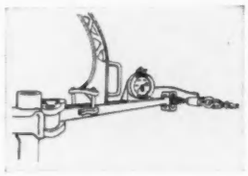

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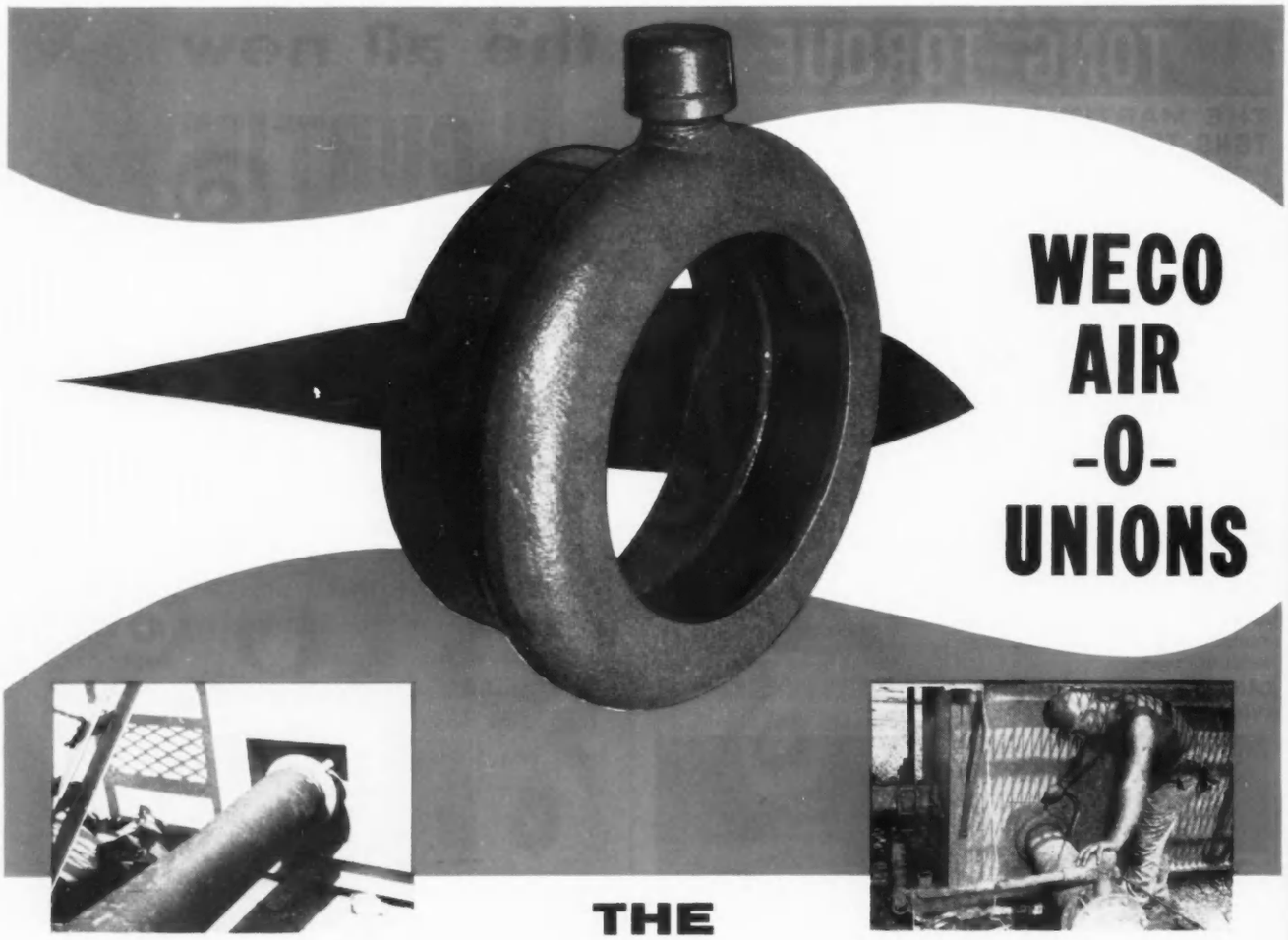

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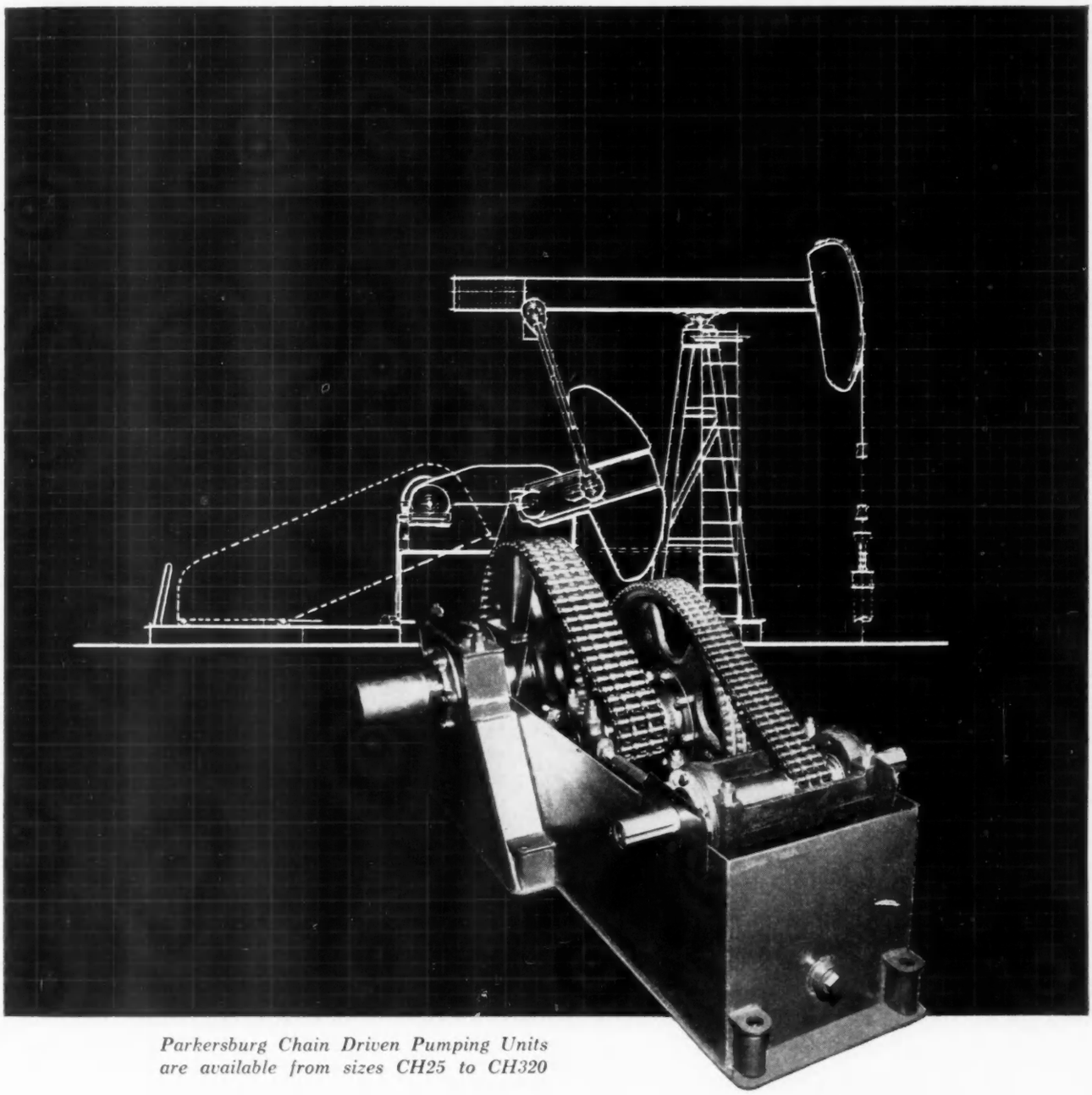

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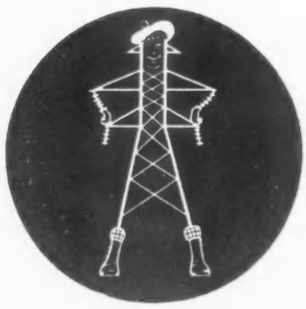

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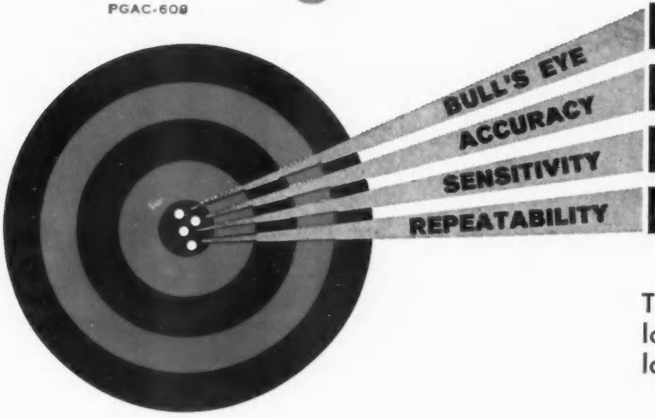

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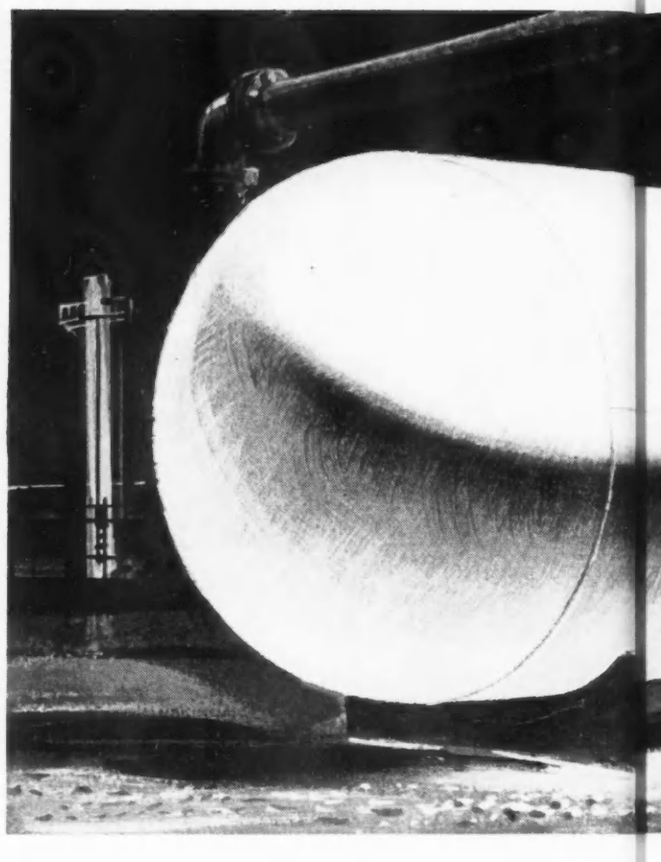

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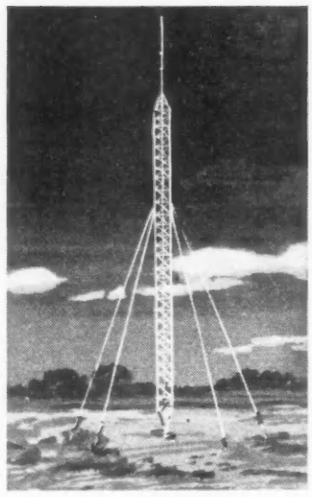

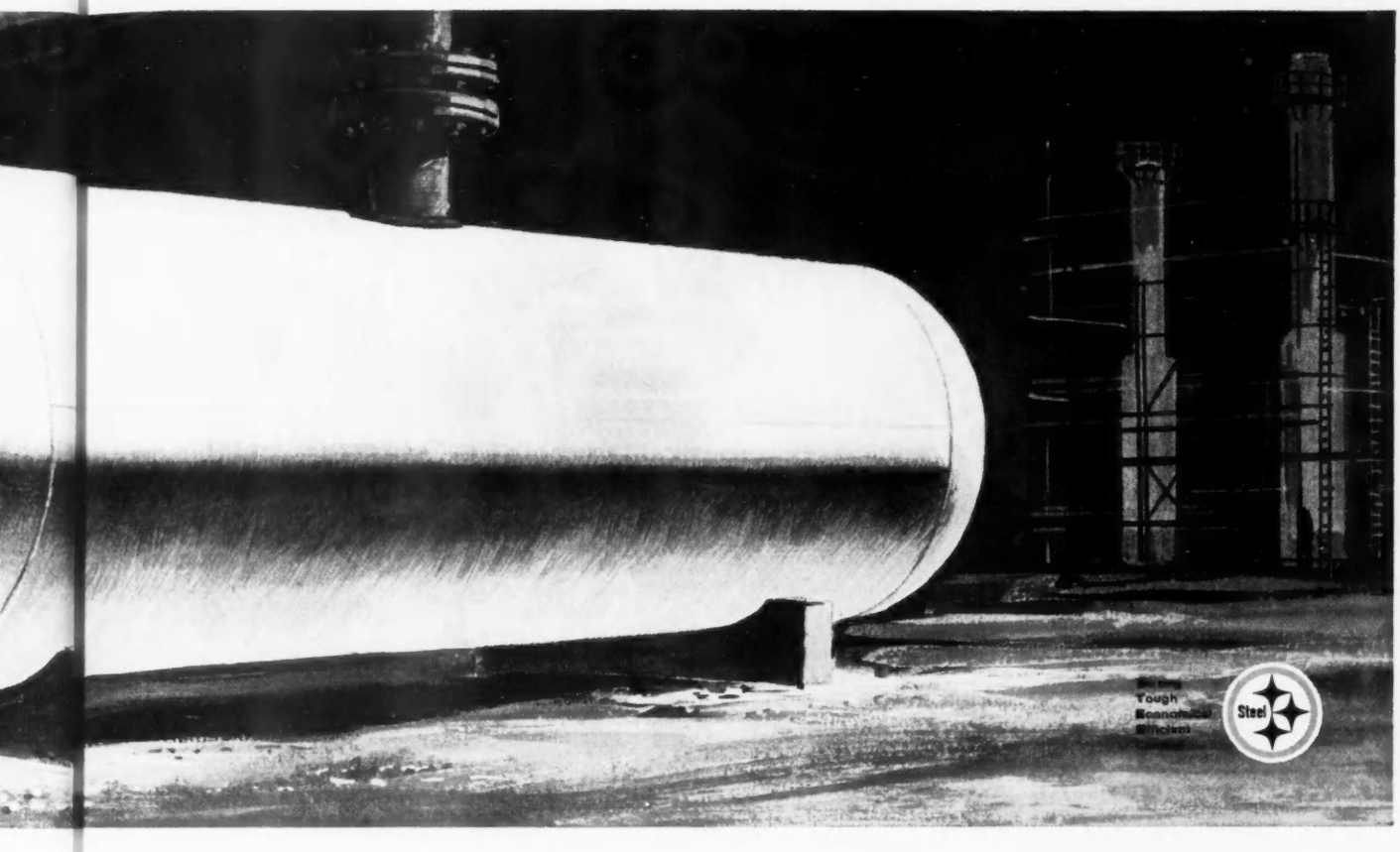

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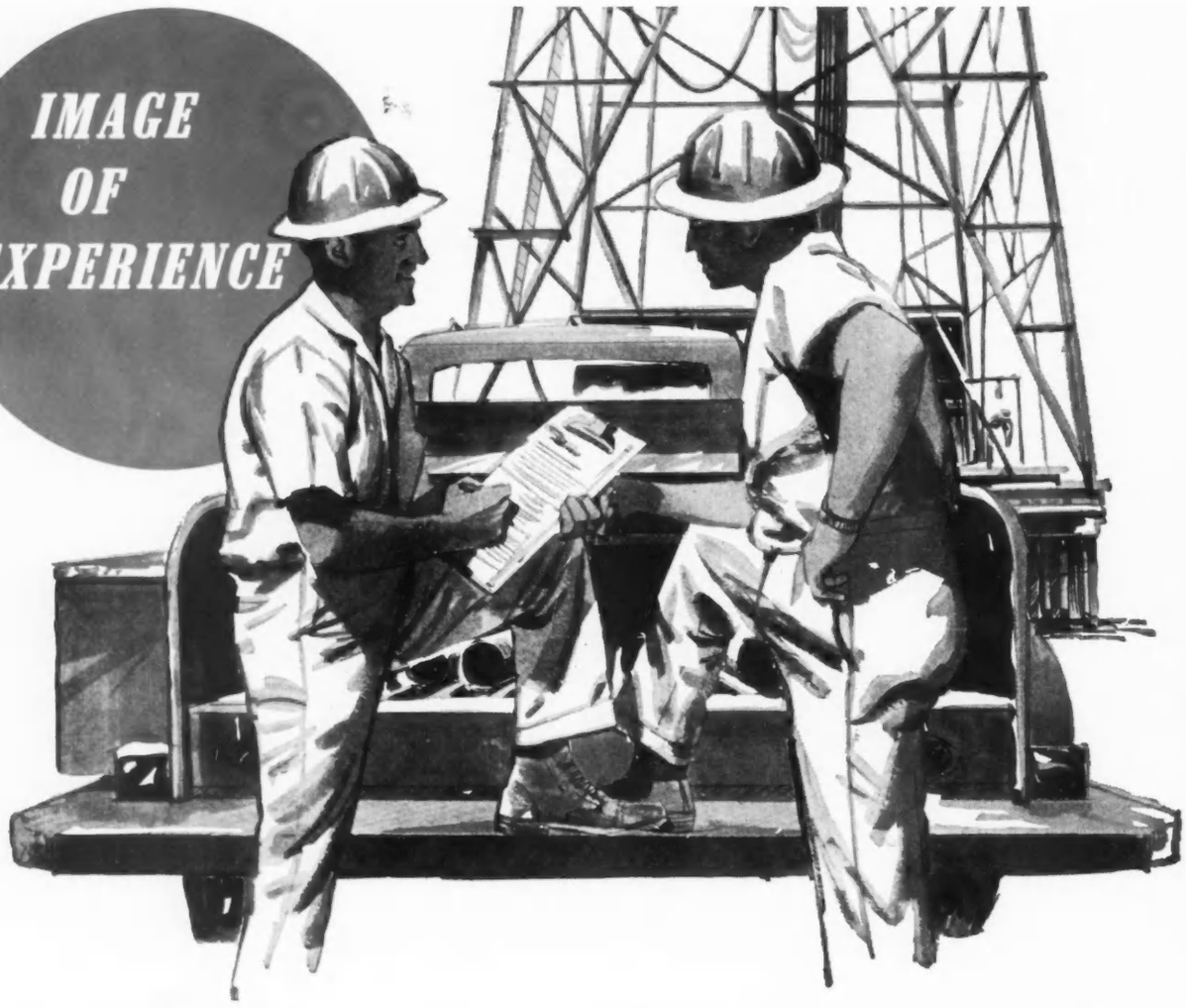

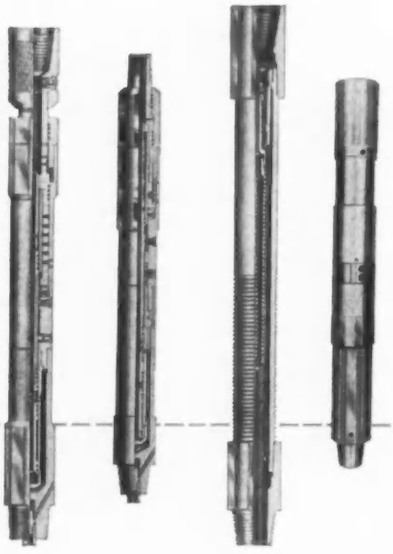

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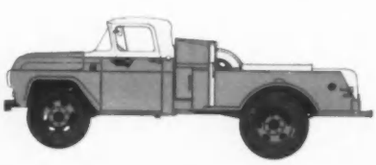

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Leaders lock horns on key energy issues

By Don E. Lambert
WORLD OIL Staff

TWENTY OIL, GAS AND COAL LEADERS, government officials and educators picked a common ground late in June to air conflicts and mutual problems concerning government relations with the fuels industries.

The common ground was the Second Annual Energy Institute held at American University in Washington, D. C. WORLD OIL was the only publication represented at the five-day meeting.

Many significant ideas were presented, both in the papers and in off-the-cuff discussions. But, perhaps most important was the agreement that oil, gas and goal are entering a new era. Paralleling this agreement was the recognition that the Administration and the Federal government continue to feel that the fuels industries are not meeting their social responsibilities in their highly competitive efforts to capture markets, supply customers and satisfy stockholders. And the government is planning to play a much stronger role in correcting this situation.

Following are some of the key thoughts expressed on four problem areas during the Institute.

1 Will oil take its cue from coal on depletion?

PETROLEUM AND COAL LEADERS agree to the need for a depletion provision. But that is where their agreement ends.

Because of the higher rate it receives, the oil and gas industry is forced to exert every effort to maintain the status quo. Coal, on the other hand, is directing its efforts toward an increase from the present 10 percent rate to 15 percent.

In presenting their arguments supporting an increased percentage, coal leaders offered some ideas of interest to oil and gas producers, i.e.:

- Congress has given some, but not enough, recognition to the problem of inflation in respect to deductions for depreciation of capital assets. Certainly, it should not go backward now and, by reducing deductions for capital exhaustion of mines (or oil and gas reserves), impose on the mineral industry the full impact of confiscation resulting from inflation.
- If capital value is to be recovered from earnings, which is the only possible source of recovery, the rate allowed for capital recovery in profitable years must be high enough to overcome the failure to make any recovery in loss years. This can be accomplished only by percentage depletion. This aspect of percentage depletion has not been eliminated by the provisions for carrying back and forward losses of the taxpayer.
- Unless profitability should improve to an extent not now foreseeable, an increase to 15 percent for coal would not bring the industry's actual average depletion provision up to anywhere near the 10 percent gross ceiling, but would tend to bring the average up somewhat above the present inadequate capital recovery.

Tax Accounting Treatment of Expenditures in the Finding, Development and Production of Oil and Gas

Expenditure	Tax Treatment
1. Dry hole costs	1. Expensed as incurred*
2. Lease rentals	2. Expensed as incurred
3. Lease acquisition costs	3. Capitalized upon acquisition
a. Leases later proved unproductive	a. Capitalized cost charged off as loss upon surrender of lease
b. Leases later proved productive	b. Capitalized cost recoverable as such only through cost depletion
4. Other exploration expense, such as geophysics, geology	4. Capitalized if on an area of interest**; otherwise expensed as incurred
a. Areas later proved unproductive	a. Capitalized costs charged off as a loss upon surrender of property
b. Areas later proved productive	b. Capitalized cost recoverable as such only through cost depletion
5. Intangible drilling costs of producing wells	5. Option to expense as incurred or to capitalize and recover through cost depletion
6. Tangible equipment on producing wells	6. Capitalized and recovered through depreciation
7. General lease equipment on producing properties	7. Capitalized and recovered through depreciation
8. Production costs	8. Expensed as incurred

* Taxpayers who have elected to capitalize intangible drilling costs have the additional option either to expense or capitalize dry hole costs. The option to capitalize intangibles is almost never used.
** An area of interest is one in which further exploratory work is at least conditionally contemplated.

Panelists at the Second Annual Energy Institute

Taxation
Richard Gonzales, director, Humble Oil & Refining Company
Richard C. Hirschberg, asst. general counsel, National Coal Association
Rolla Campbell, consultant, Island Creek Coal Company
Donald C. Harberger, University of Chicago
Stephen L. McDonald, Louisiana State University—moderator

Natural gas regulations
William Murray, chairman, Texas Railroad Commission
William Elmer, president, Texas Gas Transmission Company
Charles H. Frazier, United Gas Improvement Company of Philadelphia
Jerome J. McGrath, attorney
W. S. Goldston, president, Goldston Oil Corporation
John Boatwright, former Indiana Standard vice president, now an industry consultant—moderator.

U.S. trade policies
Minor Jameson, executive vice president, Independent Petroleum Association of America
Elmer Bennett, former Under Secretary of the Interior
Charles J. Potter, president, Rochester and Pittsburgh Coal Company
John H. Lichtblau, Petroleum Research Foundation
Carroll L. Christenson, University of Indiana
Sam Schurr, Resources for the Future, Inc.—moderator

Federal government's statistical program
Neal A. Onstot, senior analyst, Continental Oil Company
Myles Robinson, economist, National Coal Association
Rexford C. Parmelee, U.S. Bureau of Mines
Daniel Parson, Northern Illinois Gas Company
N. A. Baily, dean of American University's school of Business Administration—moderator.

Others
John Kelly, Assistant Secretary of the Interior
Frank Ikard, Congressman, Texas

Four fallacies discussed. In addition to a complete review of pro-depletion arguments, by petroleum and coal spokesmen, the anti-views also came under close scrutiny. Main arguments against the depletion provision fall into these categories:

1. There is no sound economic reason why the taxpayers should be called upon to assume some of the burdens of risk of private enterprise. *(What better alternative will provide the incentive needed to assume the high risk of finding adequate reserves for the taxpayer?—Editor's note.)*

2. Percentage depletion makes the effective income tax relatively low in the mineral producing industries, thus leads to an excessive application of labor and capital resources to the finding and production of minerals, presumably at the expense of non-mineral industries. *(This over-simplification fails to consider the fact that oil and gas operations assume heavy tax loads not imposed on non-mineral industries—Editor's note.)*

3. Percentage depletion is prejudicial to conservation in that by providing a special incentive to find and produce the affected minerals it leads to an earlier exhaustion of these scarce and non-reproducible resources. *(It also leads to bountiful supplies at reasonable cost—Editor's note.)*

4. Rate of depletion on gross income should have been reduced as tax rates increased. In that way, the value of deduction would have remained relatively constant. *(Also, fuels prices would have increased to meet the deficit—and it is generally acknowledged that technologically and economically advanced societies are those with access to cheap energy; that percentage depletion, by keeping prices low, encouraging technological advance upon which real improvement in standard of living depends—Editor's note.)*

These are some of the arguments anti-depletion advocates, many of whom have never experienced a business risk of any kind, are using and will continue to use in their efforts to scale down the present percentage rates. Logical rebuttals, based on industry experience, were presented at the Institute, and will be presented again and again in Washington.

Important among these is the oft-repeated fact that petroleum exploration and production is distinctly different from the manufacturing and trade operations that customarily serve as the basis for economic theory and analysis.

What effect this form of reasoning will have, in the face of the emotional anti-depletion approach colored by such terms as "loophole," "subsidy," "privilege," and "preferential tax treatment"—only time will tell.

2 Trade policies curb industry development

THERE ARE TWO strong schools of though on U.S. fuels trade policies. One is that imports should be restricted to provide incentive to develop adequate reserves to insure national security—incentive that appears to be working in reverse under current government policies.

The other is that this nation should encourage imports to preserve our "dwindling" reserves, improve international relations and help insure the political and economic stability of nations that are heavily dependent on oil royalties.

As one government spokesman at the Institute put it, the areas of conflict on this and other issues are so great that a national policy is needed to put competing U.S. fuels industries back in perspective in respect to their relationships with themselves, the domestic consumer and the rest of the world.

During this complex, yet highly significant phase of the Institute, competing fuels leaders discussed the effects of U.S. import-trade policies on oil, coal and the consumer. Some of the thoughts in brief:

Effect on oil. Inter-oil industry conflicts are apparent. Companies with large overseas reserves, encouraged in the first place by the federal government to find and develop those reserves, present arguments supporting relaxed import restrictions. Independent producers are just as emphatic in

their stand against the relaxing of restrictions.

In the latter vein, statistics were presented to emphasize the impact of imports on domestic crude oil production. Also, examples were given to prove that the current federal policy of restricting imports has received general industry endorsement several times during the past 25 years.

One example was an American Petroleum Institute resolution passed in November 1934, the fifth paragraph of which read:

"That the Federal Government should so regulate the importation of crude oil or refined products, as to balance production with consumer demand. Imports should be regulated to some percentage relationship to domestic production so long as this is necessary to effect the balancing of supply and consumption."

Similar endorsements were made by the Petroleum Industry War Council in 1945, the National Petroleum Council in 1949, and the National Petroleum Council with a further definition of policy in 1950. Independent producer groups have supported this philosophy for decades.

Effect on coal. Coal leaders side with independent crude oil producers on the imports issue, using many of the same arguments.

One of coal's major problems is the inequity of import-export regulations between the U.S. and other nations. Examples were given to show how coal's domestic and foreign sales have dwindled because many countries have imposed prohibitive tariff barriers against U.S. exports, while the U.S. government makes coal subject to "open and direct attack by energy imports" into this country.

The coal industry believes the federal government should either provide fossil fuels with ample protection against imported energy sources, or promote free trade in energy.

Effect on the public. Conflicting views run rampant here. On one side are those who believe current government fuels trade policies benefit the U.S. public by keeping a downward pressure on prices, protecting our "dwindling" reserves, and by strengthening the economic and political stability of our energy producing allies. On the other side are those who believe current policies will accomplish just the opposite.

Still another philosophy, gaining support in many quarters, is that since the above conflicts (plus many others) can never be resolved by the competing fuels industries, a National Fuels Policy is needed to provide an adequate analysis of the pricing patterns in fuel marketing, the national conservation goals to be achieved in the production of energy sources, a comprehensive view of our national security, and the effective maintenance of fair competitive practices in the marketing of fuels.

In short, a National Fuels Policy is expected to place everything in its proper perspective, apparently without regard for the consumer's freedom to select the fuel he prefers. Or for the freedom of industries to compete under a free enterprise system.

3 Natural gas cuts deep into coal's profits

COAL'S AGGRESSIVE CAMPAIGN against the gas industry boils down to these statistics:

In 1946, coal supplied 56 percent of U.S. fossil fuels consumption, compared with 11.6 percent by natural gas. In 1960, coal's share had dropped to 32 percent, while gas had increased to 34.3 percent of the total.

Conceding that gas is not the only contributor to their loss of domestic markets, coal leaders are pressing on these points:

1. Gas transmission companies are making off-peak industrial sales of gas "below cost," thus are taking customers coal could compete for, if prices were equitable. This practice is "wasting" a valuable resource that, according to the U.S. Supreme Court in the Consolidated Edison case, "should be limited to uses to which it should be put, uses for which another, more abundant fuel may serve equally well."

2. If all classifications of service were to bear their fair share of the costs of rendering such service, interruptible industrial rates in many areas would be higher in cost than coal. To keep from losing these sales, pipe lines are requiring the firm users to carry the costs previously borne by the interruptible users. What this also means is that coal is "subsidizing" the gas industry.

3. The best answer to conflicts between coal and gas is the utilization of underground gas storage. Not only is terminal storage the best conservation tool the pipe line companies have, but also it is the cheapest method of meeting expanded demands for firm winter deliveries of gas.

4. The utility rate base method of regulating producer prices is completely unworkable. Because of this method, natural gas for some time has been priced far below its true value as a fuel.

It is interesting to note that on more than one occasion the courts, not the Federal Power Commission, were given the blame for the inept handling of producer regulation. For the most part, long delays in court decisions on FPC methods of regulation have resulted in the ridiculous backlog of producer rate cases.

Gas industry views. Following is a brief analysis of the thoughts expressed on natural gas regulation at the Energy Institute.

► **Producers' viewpoint.** Regulation, or preferably no regulation, of producer gas prices at the wellhead must be based on legislation—not court decisions. Regulation by the judiciary, as the courts themselves have declared, is neither sound nor practical. The courts can interpret legislation, but they cannot administer regulation.

If there must be regulation, legislation prescribing area pricing and prescribing the standards upon which it should be based is urgently needed. And there is serious doubt that even this will work. Haphazard stopgap methods to comply with a completely unworkable Supreme Court decision must be eliminated if this nation is

to be assured of adequate natural gas reserves.

► **Transmission company viewpoint.** Regulation of natural gas prices is hurting the pipe lines. Legislation is needed to exempt the Federal Power Commission from applying the utility approach.

Coal is becoming more competitive, yet does not appear to be satisfied with the volume gained. Now, the industry's leaders want all gas to carry the same price at the city gate. Interruptible sales of gas are sound because the over-all cost is less.

► **Distributors' viewpoint.** The opinions of distributors on natural gas regulation vary widely, depending on distance from gas fields, relative competitive conditions in the various markets served, length of time a distributor has been serving natural gas, nature of the supply facilities, plus many other factors.

However, it is generally agreed that the tremendous backlog of FPC gas producer rate cases has seriously hampered distributor operations.

Many people recommend that this problem be solved, either legislatively or on a regulatory basis (and it is believed that either is possible), by provisions which keep to a bare minimum the regulatory requirements as they may apply to the small producers.

(As pointed out in the July WORLD OIL, *the independent producers are far from convinced that this approach will solve their problems.—Editor's note)*

► **State regulatory agency viewpoint.** A key point of discussion in this area was the possible conflict between state and federal authority on energy fuels matters. Here are some of the thoughts on this subject.

While the energy producing states have worried in the past about possible conflict between the pricing functions of the FPC and the conservation functions of the individual states, that worry has now materialized into an actual head-on collision between these functions.

Late in May, FPC announced two proposed rules changes in Dockets R-199 and R-200. One of these rules provides that a producer cannot produce more than 1 thousand cubic feet of gas per day for each 8 million cubic feet of originally dedicated reserves.

Here, for the first time the Commission is specifying a rate of production, as well as the price to be paid at the wellhead. By this action, the Commission would not only usurp the traditional, historic role of the states in establishing production rates, but also it would do extreme violence to other conservation concepts carefully worked out by the individual states over the years.

Such provisions, if adopted by FPC, would uproot most of the business practices of the industry, cast doubt on the workability of the area pricing system, but most important of all, create havoc with state conservation functions.

There is unverified word that the FPC intends to modify these proposed rules before putting them into effect. It is hoped that the Commission will recognize and avoid such conflict with state responsibilities.

4 Federal data costs solution hits a snag

The fossil fuels industries agree that:

• Federal government statistics have played a key role in the economic and political development of the United States.

• From now on fossil fuels will feel the impact of new forms of energy (solar, nuclear, etc.), Soviet competition in world markets, plus energy use and production in every country—creating a need for much broader statistical coverage in the future.

• Serious gaps now exist in the government's statistical program.

However, the fuels industries do not agree on the approach to take in filling the gaps.

According to one of the coal economists, "The basic statistical needs of the (coal) industry can best be met at the feedral level." This includes statistics on U.S. coal production, or supply; consumption, or market demand; distribution; and competitive fuels.

An oil industry economist suggests the following division of responsibility between the Federal government and the petroleum industry for collecting statistics:

► Government statistics should be directed to areas affecting national security and broad public policy, such as foreign trade, regulation, taxation, mobilization, and the general economic well-being of the nation.

► Industry sources should collect statistics which are needed at frequent intervals for making its day-to-day operating decisions. Obviously, the taxpayer cannot be expected to assume the cost of assembling and distributing these facts.

Problem areas for oil and gas

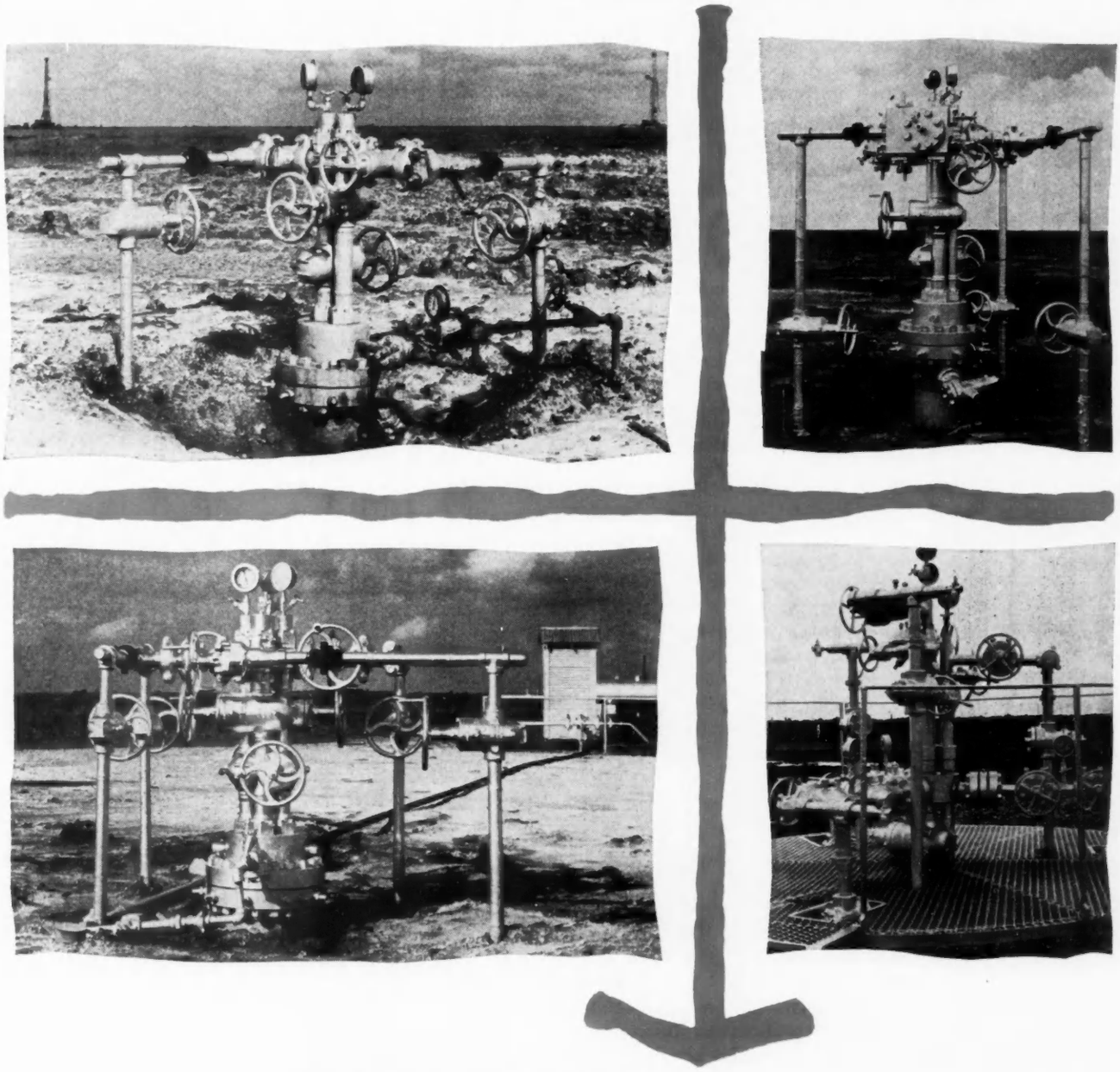
1. No one has yet been able to determine with any degree of accuracy how much oil is actually found in a given year.

2. There is a great need for figures on replacement costs of petroleum. However, there are no published studies that approach even minimum standards of reliability.

3. Approximately 40 percent of the industry's total refined product sales consists of kerosine, distillate and residual fuels. These are the products most directly affected by inter-fuel competition from natural gas and coal in industrial, utility and home heating markets. However, no definitive figures are available which show the complete end-use of these petroleum products.

4. The lack of adequate information on petroleum operations in foreign countries is a major deficiency in currently available data. Oil is the single most important item in foreign trade—measured either in dollars or in tonnage—and the government is in the best position to secure information relative to this subject.

5. Perhaps the most common complaint by users of federal statistics is the time-lag between the end of a reporting period and the publication date of the final report. —**The End**



Part I: Economics and Application

Small diameter well completions

By R. W. Scott and Jack F. Earl
Engineering Editors, WORLD OIL

DURING THE PAST FEW YEARS, small diameter well completions have increased markedly in all geographic areas of oil and gas production operations. Although the technique of using small cased wells is not new, a full range of equipment only recently has been made available in small sizes. Operators report that all types of workovers now have been conducted successfully in casing as small as 2⅞-inch OD.

Stekoll Petroleum Corporation generally is credited as the first operator to adapt small diameter wells to all types of production operations. In 1942, the company first used 2-inch line pipe as casing in shallow Mid-Continent waterflood operations.

In 1959, Humble Oil & Refining Company released information on its experience with small cased wells. Since then, Humble and other major producers have completed many wells of all types, using the small diameter technique.

Small diameter well completions have been made in practically all oil provinces in the United States and Canada. Because of the mechanical success of the technique and its economic benefits, it is anticipated that the

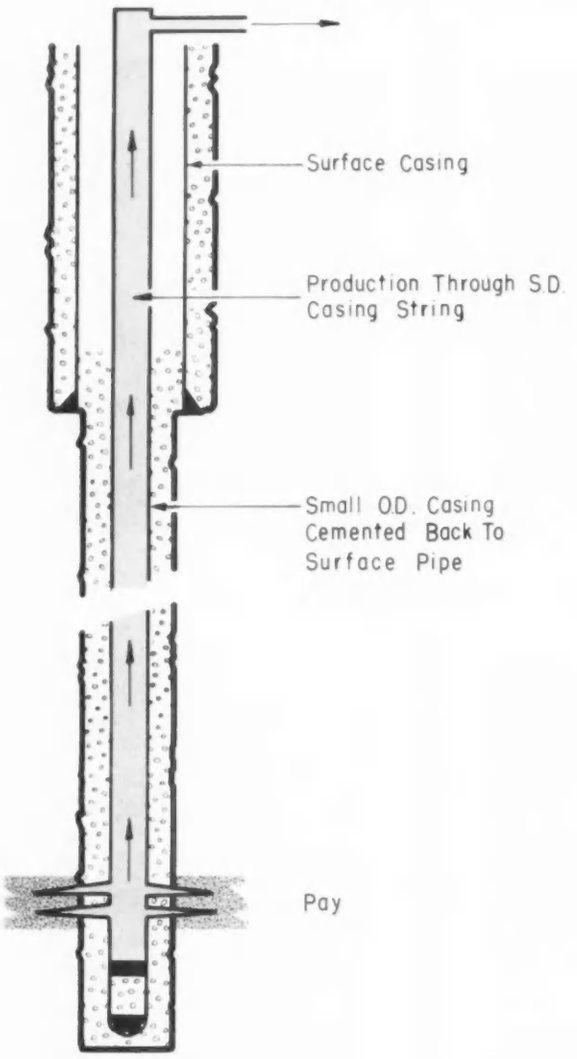


FIGURE 1—Single small diameter well completion.

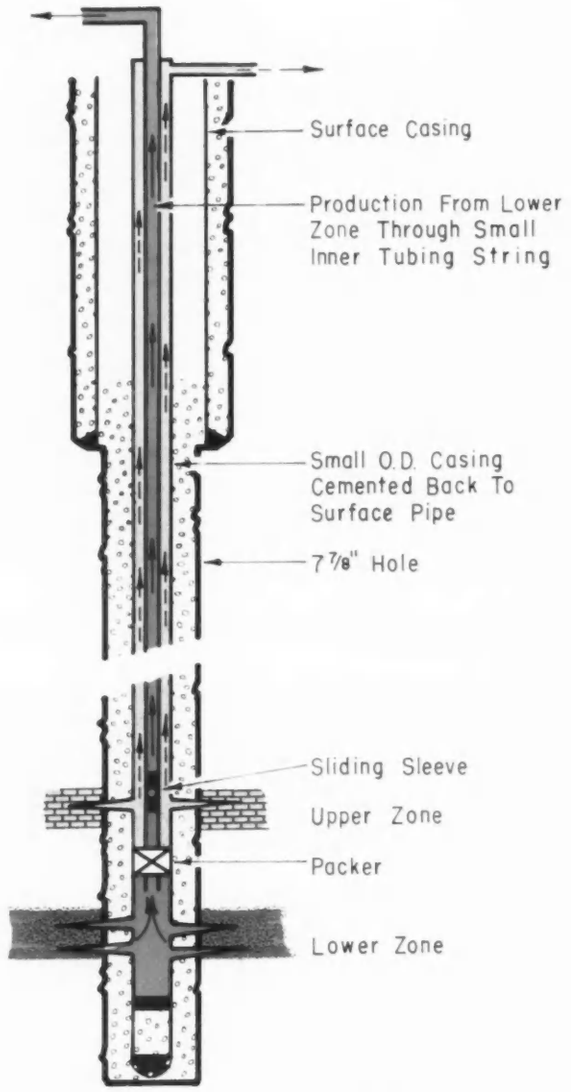


FIGURE 2—Concentric dual small diameter well completion.

procedure will grow in popularity and acceptance. For example, in one area where conditions are favorable to the small diameter cased hole, about 70 percent of one major company's completions currently utilize small diameter casing. That company did not have a single small diameter cased well three years ago.

This growing industry trend has prompted WORLD OIL to publish its Engineering Practices Report No. 4, "Small Diameter Well Completions."

To prepare this report, WORLD OIL asked operators and manufacturers of equipment throughout the United States and Canada about their experiences with the technique. In addition, a detailed literature search was conducted and all available information on the subject was compiled so that Engineering Practices Report No. 4 would include the thinking and experiences of many technical operating people throughout the oil industry.

DEFINITIONS

The small diameter well completion technique has been refined and modified considerably during the past few years. Since Humble Oil & Refining Company was the first major operator to adopt the procedure in over-all operations, much of the credit for these refinements must be given it. Other large producers since have adopted the technique and have contributed significantly in new and better methods of installing, completing and producing small cased wells.

A variety of names were proposed initially for small diameter wells, including "slim hole," "tubingless," "casingless," etc. Of all terms proposed, "tubingless completion" probably has become the most accepted.

During early work with the method, "tubingless completion" was an apt description since no inner tubing strings were used in wells cased with 2⅞-inch OD pipe. All production was handled through the casing string or through a hollow rod string in some pumping wells. As more equipment became available, however, many small diameter wells were equipped with inner tubing strings and essentially became miniaturized counterparts of conventional wells.

Thus, early terminology has become confusing for several reasons:

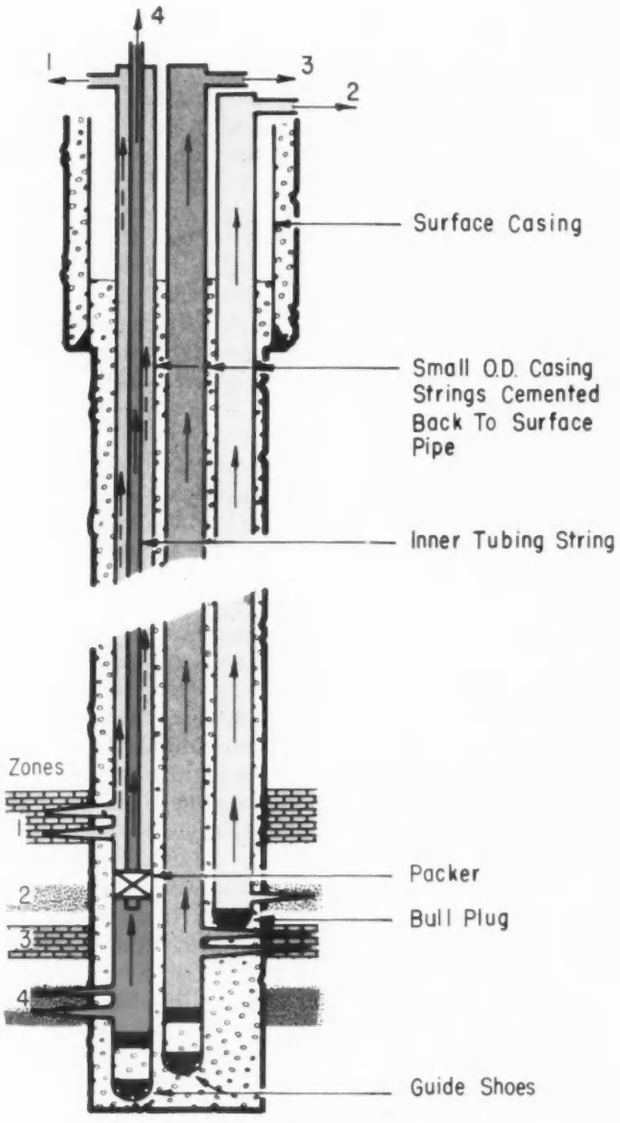


FIGURE 3—Combination parallel string (triple) and concentric multiple completion. Total producing zones—4.

• Many "tubingless completions" are equipped with tubing strings.

• All wells are equipped with a string of pipe serving as an oil casing string, which precludes use of "casingless" terminology.

• "Slim hole completion" is not entirely applicable since it has not become common practice to utilize slim hole drilling techniques in drilling the wells.

For clarity and because it can be applied generally, the term SMALL DIAMETER WELL COMPLETION has been selected to describe the completion procedure under discussion in this Engineering Practices Report.

Small diameter wells may be defined, for the purpose of this report, as wells equipped with casing that cannot receive 2⅜-inch OD tubing as an inner tubing string. The majority of small diameter wells have been equipped with 2⅞-inch API tubing, both EUE and regular, although some operators have utilized 2⅜-inch EUE API tubing and 2½-inch line pipe as casing. Also, other operators have successfully used 3½-inch OD tubing.

Single completion. A single small diameter well completion refers to a well equipped with surface pipe and one string of small diameter tubing or line pipe set as an oil casing string. Downhole producing equipment is optional and varies according to the type well (oil, gas, injection, etc.), operator preference, and the area in which it is completed. Figure 1 shows a typical single small diameter well completion.

Concentric dual completion. This type consists of surface pipe, a small diameter oil string and a smaller diameter inner tubing string set on a pack-off assembly. The completion is utilized in the same manner as early type conventional dual completions. That is, zones are perforated above and below the pack-off assembly point. One zone is produced through the concentric tubing string—usually 1¼-inch OD or 1½-inch OD if 2⅞-inch OD casing is used—and the other zone is produced through the tubing-casing annulus.

Downhole equipment again is optional although most operators use some type of circulating valve (generally a sliding sleeve) on the small inner tubing string. Conventional packers may be used, or pipe may be set and packed off in a landing nipple. Also, cross-over equipment may be used, if desired. Figure 2 shows a typical concentric dual small diameter well completion.

Parallel multiple completions. These wells are equipped with adequately sized surface pipe to pass the required number of oil strings and either 2, 3 or 4 small diameter oil casing strings, depending on the type completion to be made, whether dual, triple, quadruple, etc. (Figure 3).

Again, downhole equipment requirements will depend on varying factors and operator preference. At this writing, as many as four oil strings have been set.

It should be mentioned that combination surface strings have been run to accommodate 12-inch blowout preventer hook-ups required to pass quadruple tubing hangers. In such cases, a single joint of 13⅜-inch casing is run at the top of the normally-used 10¾-inch surface string.

Combination parallel and concentric multiple completion. Wells of this type have been completed extensively in South Texas oil and gas zones. In such cases, multiple oil strings are run and cemented. (To be discussed in Engineering Practices Report No. 4, Parts 2 and 3, in the September and October issues of WORLD OIL.) Small concentric tubing strings then are installed in each oil string, resulting in two or more (depending on the number of oil strings) concentric dual completions in the same bore hole (Figure 3).

For example, if sufficient reservoirs are present in a given case, it is conceivable that eight separate zones could be produced from a well having four strings of 2⅞-inch casing and four smaller inner tubing strings. The well actually would consist of four concentric dual completions in a single bore hole.

The preceding discussion illustrates types of small diameter well completions made to date. Inner tubing strings with gas lift valves or rod pumping equipment are commonly used to lift oil wells and hydraulic pumping installations also have proved successful. A detailed

discussion of this phase of small diameter well operations will appear in a later section of this Report.

ECONOMICS AND APPLICATION

Small diameter well completions have been used successfully in most major oil and gas producing areas to depth in excess of 12,000 feet. Although many such completions have been made, some areas still present problems which make successful small diameter well completions—and especially parallel multiple completions—difficult.

Of the many operators contacted in preparing this report, almost all have reservations as to the over-all application of small diameter wells. The concensus is that significant savings can be made if the procedure is applied judiciously on a selective area basis.

Advantages. Most operators have one basic reason for using small diameter well completions—they cost less money. However, there are a considerable number of secondary considerations relating to economics of the procedure in general.

The following reasons are those most often cited by operators for using small diameter well completions. Once again, it should be emphasized that these remarks are based on factors in a specific area. All of them will not apply to operations in general.

1. Smaller investment. Initial equipment investment is reduced and payout is obtained in a relatively short time. Chief savings are obtained through elimination of large OD oil casing strings.

2. Small reservoirs can be depleted economically. These reservoirs normally would not support expenditure of larger sums of money required for conventional completions.

3. Capital saved is readily available for investment. One operator has estimated that enough money is saved in the drilling of seven small diameter completions to drill an additional well. This factor, of course, will vary with area and type of completion contemplated.

4. Maximum return per dollar invested. Since most U.S. production is prorated and since small cased wells will adequately produce these prorated volumes of fluid under normal conditions, some operators feel there is no reason to spend additional money for larger equipment to produce the same amount of oil.

Of course, this reasoning is based on the assumption that allowables will not be raised substantially in the foreseeable future and that they will remain within the producing capacity of the small cased wells.

One operator cites this example: a conventional well costing $100,000 can produce only 90 barrels per day under state proration. A small diameter well in the same field costs $80,000, but it also can produce only 90 barrels per day. So the small diameter well is more practical from an economic standpoint.

On the other hand, a well with substantial producing potential in a non-prorated state might be restricted by small casing.

5. Excellent means of testing questionable pay zones at depth in new wells without expenditure of large sums of money for larger size casing. This is extremely helpful in areas where stimulation is required before the true potential of a well is revealed. Obviously, it is much easier—and cheaper—for an operator to decide to set 2⅞-inch pipe on a questionable well instead of 7-inch pipe.

6. Old wells previously considered dry or non-commercial can be re-entered at minimum cost and tested. Usually, the old hole is cleaned out with a 2⅞-inch tubing string equipped with bit, latch cementing equipment and safety joint. After clean-out to bottom, the string is cemented in place through the bit. Only one trip is required for the complete operation. If the well is dry, tubing is backed off at the safety joint, which is positioned above the cement fill-up point, and recovered.

7. Completion costs can be reduced. Once cement plugs are bumped, the rig can be released (if well has been cemented through the tree). Thereafter, all logging, perforating, etc. is done with service company equipment by the wireline method.

8. Parallel multiple small diameter well completions permit positive segregation of producing intervals in a single bore hole. This type completion is especially advantageous if applied in an area where the multiple zones encountered are susceptible to damage from mud or workover fluids.

In many cases, good productive zones in conventional multiple completions have been damaged beyond repair during workover of other intervals in the well. This method allows the operator to treat each small diameter casing string of the multiple as an individual well. Each may be worked over without exposing the others to damage. In fact, it is often unnecessary to shut in other producing wells in a parallel completion while one is being worked over.

9. Workover costs are often considerably less than those required for conventional completions. In many cases, the complete workover can be performed without a rig by wireline tools.

10. Parallel multiple completions are the most economical means of preventing drainage by offset operators. Conversely, if an operator is offset by this type completion, he is almost forced to duplicate the technique if he is to remain competitive cost-wise.

11. Cheaper secondary development. According to one operator, a carefully planned secondary small diameter development program may result in 25% savings on producing wells and 30% on injection wells, compared with conventional drilling and completion methods.

In the above instance, small diameter savings on 3,000-foot producing wells amounted to 38.3% on surface casing, 49% on production string and 27.8% on pumping string—for an average saving of 40.5%.

For the same depth injection well, savings amounted to 38.3% on surface casing and 54.8% on the injection string—for an average saving of 51.8%.

12. Indirect cost reductions. Several other economies have been made which are outgrowths of the philosophy rather than the mechanics of small diameter well completions. One is the reduction in perforating cost due to decreased shot density. Another is the cost reduction of sand fracturing and squeeze cementing jobs by using low volume and low pressure squeeze methods.

Satisfactory results obtained with these techniques by several operators in different areas indicate these cost reduction possibilities and others will be studied closely with the adoption of small diameter well programs by other companies.

13. Equipment availability. All types of artificial lift

TABLE 1—Small Diameter vs. Conventional Cost for Single Completions in Different Areas (1958-1961)

AREA	Depth In Feet	Small Diameter (2⅞ Inch)	Conventional Hole	Savings	Average Percent Savings
California (11 wells)	970–4,380	.....	(5½")	.....	11
West Texas (20 wells)	1,500–3,300	.....	(4½"–5½")	.....	16
Texas Panhandle	3,000	$23,500	$29,400 (5½")	$5,900	25
Eastern-Central Okla.	3,400	.....	(4½")	.....	17
Canada (Pembina field)	5,000	37,500	52,200 (5½")	14,700	28
Wyoming (Desert Springs)	6,000	62,000	99,000 (5½")	37,000	37
South Texas	6,700	37,400	65,450 (5½")	28,050	43
South Texas	6,800	38,150	50,700 (5½")	12,550	16
South Texas	6,800	38,150	45,550 (4½")	7,400	11
Eastern-Central Okla.	7,100	.....	(4½")	.....	17

programs, well stimulation techniques, workover operations and sand control methods have been applied successfully and economically to small diameter well completions. Since adequate miniaturized tools are available, there are few mechanical reasons for not attempting the procedure.

Tables 1 and 2 show general cost comparisons of small diameter vs. conventional wells as reported by operators in different areas.

Disadvantages. Many operators, however, are reluctant to attempt small diameter well completions. Some who have experimented briefly with the technique have been less than impressed with results—especially if the completion resulted in expenditure of more money than a conventional well.

As is the case in many new oil field developments, diverse opinions exist even in companies successfully applying the technique. For example, one district of a major company successfully utilizes small diameter wells while another will not consider even one more because of exceptionally poor results. Valid reasons for these poor results exist, and in most cases they support the view that such wells are applicable on an area basis only.

However, it should be kept in mind that experience is probably the most valuable asset an operator possesses in applying the small diameter well completion. Companies which have actively pursued the technique have made great strides in solving many of the problems initially encountered and previously considered insurmountable.

The following disadvantages of the procedure were compiled from operator experience:

1. Restricts production. Productivity can be restricted by use of small diameter casing, especially in highly productive water drive reservoirs. For example, there are many areas in which wells produce top allowable with very high water cut. If artificial lift equipment were required to lift these large fluid volumes, an operator would be hindered by the small cased well, and allowable production often could not be obtained.

2. Corrosion can be a problem if small diameter wells are produced without inner tubing strings. In this case, corrosion attack is concentrated on the casing string proper, which can result in extensive well damage and casing failure.

3. The technique is not suited to areas which require very high rate fracture treatments to obtain good productivities. However, recent development of fracture fluid friction reducing additives have enabled operators to fracture 2⅞-inch cased wells at rates comparable to those previously obtained in 5½-inch casing in the same area.

4. Small diameter wells cannot be deepened for appreciable depths below the cemented casing. This fact could cause considerable difficulty if an operator who utilizes only small diameter wells were offset by conventional completions and deeper pays were discovered. This occurred in one instance, at least.

5. Washover of large inner tubing strings is impossible because of pipe clearances. This may prompt increasing use of 3½-inch OD casing.

6. Primary cement jobs have been difficult to get on parallel multiple completions. This is, perhaps, the most serious problem encountered so far. One operator has experienced 100 percent failure in obtaining primary cement jobs on triple string wells.

7. Most operators do not apply the technique in areas which have reservoirs of long anticipated life. Reasons: corrosion and because several workovers are likely to be required during the life of the well. In general, operators do not like to work in a well with macaroni strings unless necessary.

8. Most workover rig crews are not trained in the use of small size equipment. If proper caution is not exercised by rig crews and close supervision is not available, the hole can be easily—and quickly—junked.

9. Indiscrimate use of expensive, specialized equipment in small diameter wells can rapidly alter economics of the technique. Costs then can easily approach those of a conventional size completion.

10. Caution must be exercised if small diameter wells are swabbed to completion. Lost swabs (prior to use of new aluminum types which are equipped with shear pins and are subject to removal with acid) have caused junked holes.

11. Crooked casing can be a serious problem. Because of limiting drift diameter, pipe must be straight and free

TABLE 2—Small Diameter vs. Conventional Cost for Multiple Well Completions in Different Areas

AREA	No. SD Casing Strings	Depth In Feet	Small Diameter Cost (2⅞")	Conventional Cost	Savings	Percent Saving
South Texas	2	6,800	$ 47,100	$52,637 (5½" x 2" concentric)	$ 5,537	11
South Texas	2	6,800	47,100	$47,500 (4½" x 2" concentric)	400	1
South Texas	3	6,800	60,420	$72,700 (7" x 2" x 2" x annulus)	12,280	17
South Texas	3	6,800	78,000	$145,000 (2 7" x 2" x 2" x annulus)	67,000	46
Gulf Coast	2	7,200	86,100	$96,800 (5½" x 2" x 1¼")	10,700	11
Gulf Coast	2	7,200	86,100	$110,500 (7" x 2" x 2")	24,400	22
New Mexico	2	7,500	116,000 (4½" x 2⅞" cas. strings)	$117,000 (2-4½" x 2")	1,000	1

Note: Recent experience of one operator includes 56 tubingless completions in Texas and Louisiana. Nineteen of these wells are included in three triple completions and five dual completions. The 37 single completions have been made at depths from 1,400 to 10,000 feet, and average savings indicated for those wells represent 19 percent of conventional well cost.

TABLE 3—Itemized Cost Breakdown for 6,800-Foot Small Diameter and Conventional Wells in South Texas-Gulf Coast Area.

	Conventional Single Completion	Slim Hole Single Completion	Small Diameter Single Completion	Conventional Dual Completion	Slim Hole Dual Completion	Small Diameter Dual Completion	Conventional Triple Completion	Small Diameter Triple Completion	Triple Tubing String Dual Completion Each String
Surface Casing	8⅝" O.D.	8⅝" O.D.	8⅝" O.D.	8⅝" O.D.	8⅝" O.D.	8⅝" O.D.	10¾" O.D.	9⅝" O.D.	9⅝" O.D.
Production Casing	5½" O.D.	4½" O.D.	2⅞" O.D.	5½" O.D.	4½" O.D.	2⅞" O.D.	7" O.D.	2⅞" O.D.	2⅞" O.D.
Tubing	2⅜" O.D.	2⅜" O.D.	.....	2⅜" O.D.	2⅜" O.D.	.....	2⅜" O.D.	.....	1½" O.D.
Intangible Cost									
Drilling	$17,000	$17,000	$17,000	$17,000	$17,000	$17,000	$17,000	$17,000	$17,000
Day Work	1,300	1,300	1,300	1,950	1,950	1,950	3,750	1,950	1,950
Cementing	1,250	1,250	1,250	1,250	1,250	1,250	2,400	2,400	2,400
Logging (I.E.S.,N.)	1,646	1,646	1,646	1,646	1,646	1,900	1,646	2,400	2,400
Coring (S.W.C.)	900	900	900	900	900	900	900	900	900
Perforating	400	400	450	650	650	1,302	890	1,590	1,984
Casing Supplies	767	737	673	767	737	1,103	925	1,100	1,250
Drilling Mud	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Special Completion Rig	.....	.....	.....	.....	.....	.....	.....	750	1,500
Contingencies	2,800	2,800	2,800	2,900	2,900	3,000	3,200	3,300	3,500
Total Intangibles	**$28,063**	**$28,033**	**$28,019**	**$29,066**	**$29,033**	**$30,405**	**$32,700**	**$33,400**	**$34,894**
Tangible									
Surface Casing	$ 2,823	$ 2,823	$ 2,823	$ 2,823	$ 2,823	$ 2,823	$ 3,735	$ 3,660	$ 3,660
Production Casing	13,124	8,025	6,120	13,124	8,025	12,240	18,088	18,360	18,360
Tubing	4,624	4,624	.....	4,624	4,624	.....	9,250	.....	10,000
Wellhead	1,600	1,500	1,200	2,100	2,100	1,600	5,700	5,000	6,000
Subsurface	550	550	.....	900	900	.....	3,200	.....	2,400
Total Tangibles	**$22,621**	**$17,522**	**$10,143**	**$23,571**	**$18,472**	**$16,663**	**$39,973**	**$27,020**	**$40,420**
TOTAL COST	**$50,684**	**$45,555**	**$38,162**	**$52,637**	**$47,505**	**$47,068**	**$72,673**	**$60,420**	**$75,314**
No. of Wells Needed	6	6	6	3	3	3	2	2	1
Total Cost of Development	$304,104	$273,330	$228,972	$157,911	$142,515	$141,204	$145,346	$120,840	$ 75,314
Profit to Investment Ratio	**0.15**	**0.30**	**0.55**	**1.25**	**1.49**	**1.50**	**1.45**	**1.94**	**3.71**

of kinks to allow passage of logging, perforating and other downhole tools.

12. Sand production can pose a problem if it is consistent and cannot be controlled by conventional means. Repeated workovers may be required in the small casing and chances of junked macaroni strings are increased.

13. If circulating type bottom hole heaters are required (as in California), small diameter casing is not feasible.

Table 3 shows specific cost reports on small diameter vs. conventional wells, as reported by operators in different areas.

Planning. Experience has shown good job planning is essential for successful small diameter well completions. Most operators currently use engineering personnel on small diameter wells to closely supervise the complete operation.

Some companies have adopted the practice of calling a meeting of all field personnel when small diameter well completions are initiated in an area. All factors involved are discussed and explained prior to the job, so personnel can be briefed thoroughly on correct means of performing individual phases of the job.

One important point always should be made: old concepts must be forgotten. For example, workovers with macaroni tubing at 10,000 feet obviously cannot be conducted using techniques normally applied with 4½-inch drill pipe at the same depth. Once this point is clear, failures due to personnel misjudgment are curtailed sharply.

The following procedure is recommended for an operator initiating a small diameter well program:

1. Get all available information resulting from other operators' experience.

2. Educate field personnel prior to the job, and closely supervise initial work.

3. On workovers, emphasize that equipment used is "miniaturized," hence, constant caution should be exercised to prevent failures by mishandling.

4. Plan each job thoroughly from beginning to end.

5. Think *small*.

DRILLING

Drilling techniques and practices for small diameter well completions do not vary extensively from conventional completions.

Recommended hole sizes for small diameter completion programs are indicated in Table 4. Since dual, triple and quadruple small diameter completions use standard hole sizes, the following discussion will exclude these sizes and present only those techniques used in drilling actual slim holes (6¾-inch or less).

TABLE 4—Hole-Casing Size Relationship

TYPE WELL	SURFACE		PRODUCTION	
	Hole	Casing	Hole	Casing
Single	9⅞–11¾	7, 7⅝, 8⅝	6⅛–6¾	2⅞
Dual	11¾	8⅝	7⅞	2–2⅞
Triple	12¼	9⅝	8¾	3–2⅞
Quadruple	12¼	10¾	9⅞	4–2⅞

Why drill slim holes? Slim holes can be drilled cheaper than conventional holes if drilling techniques and equipment are applied properly. Table 5 illustrates that use of drill tubing, or equivalent thin wall drill pipe, will lower weight and horsepower requirements by about 40%. At the same time, required hydraulic horsepower remains constant, or increases only slightly.

In addition to a substantial reduction in rig requirements, there are tangible savings in fuel, maintenance,

TABLE 5—Comparison of Slim Hole to Conventional Rig Requirements

HOLE SIZE	*Drill String With Collars	Weight Of Drill String In Air (Lbs.)	Drawworks Engine H.P. (Input)	**Total Pressure Loss-PSI	Hyd. H.P. At Pump Sheave
6⅛-6¼	2⅞- 6.5#	62,800	246	1026	123
	3½- 9.3#	76,800	300	801	89
	3½-13.3#	96,800	376	880	97
5,000 feet 6¾	3½- 9.3#	79,400	310	947	130
	3½-13.3#	99,500	386	1094	150
	4 -14.0#	103,000	400	856	110
7⅞	3½-13.3#	99,400	385	1215	251
	4 -14.0#	107,300	418	857	169
	4½-16.6#	116,800	455	786	141
6⅛-6¼	2⅞- 6.5#	79,300	310	1241	149
	3½- 9.3#	99,900	435	872	97
	3½-13.3#	132,900	515	961	106
7,500 feet 6¾	3½- 9.3#	113,400	441	1040	143
	3½-13.3#	127,100	496	1251	172
	4 -14.0#	139,600	544	936	120
7⅞	3½-13.3#	133,900	521	1497	309
	4 -14.0#	146,300	570	972	192
	4½-16.6#	161,800	620	857	154

* Drill pipe with sufficient number of collars to allow carrying approximately 4,000# per inch of bit.
** Assuming an annular velocity maintained at 120 ft./min.; jet velocity of 250 ft./sec.

insurance, depreciation, moving cost, rig up and rig down cost, wireline, and other supplies. Labor, taxes, bits, and other fixed costs represent about 55% of the total cost of a well.

The remaining 45% is the area in which savings in rig requirements may be found. Considering a conservative 25% saving on a slim hole rig operation, the over-all savings that would result in this type of operation would amount to 10-12%.

A drilling fluid savings also may result. There is 25% less drilling fluid required in a 6¾-inch hole than in a 7⅞-inch hole, and 37% less if a 6¼-inch hole is drilled. This reduces not only water and mud costs but also earthen reserve and steel pit sizes. Some slim hole con- operator most obtain drilling performances in small holes partitions.

Streamlining of rigs and drill strings alone will not provide a more economical operation. In addition, the operator must obtain drilling performance in small holes comparable to those in conventional hole sizes.

Two key factors in the area of drilling performances, of course, are penetration rate and feet drilled per bit. Penetration rate in slim hole drilling of relatively soft unconsolidated formations compares favorably with rates in conventional hole sizes. This has been found true in South Louisiana, Mississippi and the Gulf Coast area. Also, the amount of footage drilled per bit is favorable, permitting possible net reduction in drilling costs in these areas.

In 113 slim hole wells drilled in the Denver-Julesburg Basin, savings on contract footage amounted to about $100,000. These wells averaged 5,500 feet in depth, and most drilling was with soft formation bits—except for the last bit in each well, which was a medium hard bit.

Slim hole drilling in Canada has been more a combination of soft, medium-hard and hard formation drilling. Experience on 20 slim holes in Canada indicates that penetration rates are approximately the same as with conventional holes. However, other economic advantages in slim hole drilling were found to offset the increased cost caused by higher bit consumption. Light rigs and light drill strings play more important roles where roads and locations are major costs.

Definitions of hard or soft drilling are necessary since the terms vary in meaning throughout the country. In the western half of Texas and eastern half of New Mexico, Permian age beds vary from soft to medium soft in the redbeds, salt and anhydrite sections to medium hard to hard in dense dolomites and sands. The Pennsylvanian aged beds should be classified as medium hard to hard, and pre-Pennsylvanian beds as hard to very hard.

Slim hole operations. In recommending slim hole (6⅛-6¾-inch) operations, drilling factors to be considered, of course, include:

- Size of hole
- Size and type of drill pipe or tubing
- Hydraulic requirements
- Rig and component equipment
- Bits
- Fishing equipment

Hole size. After several years of drilling 4¾-inch to 7⅞-inch holes, economics and drilling results indicate the 6¾-inch size is the most favorable.

An AAODC survey was conducted recently to find the most popular hole sizes being used. One hundred and thirty-one companies participating in slim hole work, it was found, had drilled 3,216 wells with well bores 6¾-inch or smaller. Depth of slim holes drilled by these companies ranged from an average minimum of 3,115

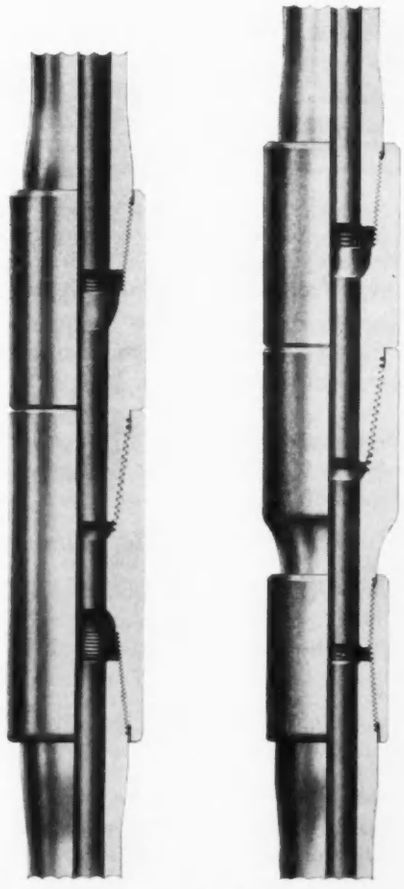


FIGURE 4—Tool joints for 2⅞-inch drill tubing.

TABLE 6—Slim Hole Hydraulic Data

	Assumed Case I	Proposed Hydraulic Program to 3350 Feet	Proposed Hydraulic Program From 3350 Feet to 7000 Feet
SURFACE EQUIPMENT			
Pump:			
Piston Size	5″	5″	5″
Length of Stroke	10″	10″	10″
Strokes per Minute	55 (Minimum)	48 (Minimum)	48 (Minimum)
Standpipe I.D. x Length	3″ I.D. x 40 Foot	3″ I.D. x 40 Foot	3″ I.D. x 40 Foot
Hose I.D. x Length	2″ I.D. x 45 Foot	2″ I.D. x 45 Foot	2″ I.D. x 45 Foot
Swivel I.D. x Length	2″ I.D. x 4 Foot	2″ I.D. x 4 Foot	2″ I.D. x 4 Foot
Kelley I.D. x Length	2¼″ I.D. x 40 Foot	2¼″ I.D. x 40 Foot	2¼″ I.D. x 40 Foot
DRILLING EQUIPMENT			
Size Hole	6¼″	6¼″	6¼″
Drill Stem: Size Wt	2⅞″ N-80 Tubing 6.50 lb.	2⅞″ N-80 Tubing 6.50 lb.	2⅞″ N-80 Tubing 6.50 lb.
Type Tool Joints	OMSCO—Thread IF	OMSCO—Thread IF	OMSCO—Thread IF
Tool Joint O.D. I.D.	2 7/16″ I.D.	2 7/16″ I.D.	2 7/16″ I.D.
Drill Collars: Total Length	270 Feet	270 Feet	270 Feet
O.D. I.D.	O.D. 3½″ x I.D. 2″	O.D. 3½″ x I.D. 2″	O.D. 3½″ x I.D. 2″
Mud Type	12.5% Oil Base at 5700 Feet	12.5% Oil Base at 5700 Feet	12.5% Oil Base at 5700 Feet
Mud Weight Lbs. per Gallon	Assume 10 lb. per Gallon	Assume 10 lb. per Gallon	Assume 10 lb. per Gallon
(1) Circulation Rate: In Gallons per Minute	(Minimum) 230	(Minimum) 200	(Minimum) 140
(2) Size of Liners	6″	6″	5″
(3) Number and Size of Bit Nozzles	3—13/32″	3—3/8″	3—5/16″
PRESSURE LOSSES FOR 1000 FT. OF DRILL STEM PLUS COLLARS AND BIT			
(4) Through Surface Equipment	45 Psi.	35 Psi.	18 Psi
(5) Through 1000 Ft. of Drill Stem	197 Psi.	152 Psi.	78 Psi.
(6) Through Drill Collar Bore	141 Psi.	108 Psi.	57 Psi.
(7) Through Bit Nozzles	323 Psi.	335 Psi.	341 Psi.
(8) Around Drill Collars	13 Psi	8 Psi.	6 Psi.
(9) Around 1000 Ft. of Drill Stem	20 Psi.	15 Psi.	8 Psi.
(10) Total Pressure Loss—Items (4) Through (9)	739 Psi.	653 Psi.	508 Psi.
(11) Total Pressure Loss Corrected for Mud Weight: (Line 10)/10 x Mud Weight = ——/10 x ——:	10/10 x 739 = 739 Psi.	10/10 x 653 = 653 Psi.	10/10 x 508 = 508 Psi.
(12) Depth: 1000 Feet of Drill Stem Plus ——Feet Drill Collars =	+ 270 Ft. = 1270 Ft.	+ 270 Ft. = 1270 Ft.	+ 270 Ft. = 1270 Ft.
ADDITIONAL PIPE THAT CAN BE ADDED BEFORE REACHING RATED PUMP CAPACITY			
(13) Pressure Rating of Pump	(Actual Usage) 1000 Psi.	(Actual Usage) 1000 Psi.	(Actual Usage) 1000 Psi.
(14) Pressure Loss for First 1000 Ft. of Drill Stem Plus Collars and Bit (Same as Line (11) Above)	739 Psi.	653 Psi.	508 Psi.
(15) Pressure Remaining for Addition of More Pipe Subtract Line (14) from Line (13)	261 Psi.	347 Psi.	492 Psi.
(16) Pressure Loss for Each Additional 1000 Feet of Drill Stem Line (5) Plus Line (9) = ——Plus—— =	197 + 20 = 217 Psi.	152 + 15 = 167 Psi.	78 + 8 = 86 Psi.
(17) Line (16) Corrected for Mud Weight: (Line 16)/10 x Mud Weight = ——/10 x ——	10/10 x 217 = 217 Psi.	10/10 x 167 = 167 Psi.	10/10 x 86 = 86 Psi.
(18) Footage That Can be Added = Line (15)/Line (17) x 1000 = —— x 1000 =	261/217 x 1000 = 1200 Ft.	347/167 x 1000 = 2080 Ft.	492/86 x 1000 = 5730 Ft.
(19) Depth at Which Pump Will be Fully Loaded: Line (12) Plus Line (18) = —— + —— =	1200 + 1270 = 2470 Ft.	2080 + 1270 = 3350 Ft.	1270 + 5730 = 7000 Ft.
(20) Input Horsepower Required at This Depth: ——IHP/Psi. x ——Psi. =	.158 IHP/Psi. x 1000 = 158 IHP	.137 IHP/Psi. x 1000 = 137 IHP	.096 IHP/Psi. x 1000 = 96 IHP
Annular Velocity in Feet per Minute	200 Ft./Min.	175 Ft./Min.	117 Ft./Min.
Nozzle Velocity	189 Ft./Second	193 Ft./Second	195 Ft./Second

feet to an average maximum of 6,580 feet, with an average depth of 4,515 feet for all slim holes reported.

Eighty percent of the surveyed companies considered 6⅛-inch through 6¾-inch sizes best. Ten percent favored holes smaller than 6⅛-inch.

Size and type of drill string. Light drilling strings of tubing equipped with tool joints are being used extensively to depths of 10,000 feet.

The two strings commonly being used are:

1. 2⅞-inch OD, Range 2, 6.5-pound N-80 tubing with 4⅛-inch OD, 2⅞-inch IF tool joints screwed on the tubing and 5¼-inch OD x 2¼-inch ID drill collars (see Figure 4).

2. 3½-inch, 9.5-pound drill pipe with 4¾-inch OD tool joints and drill collars.

Current practice is to run 15-20 joints of 3½-inch or 4½-inch OD drill pipe immediately above the drill collars (in the 2⅞-inch drill tubing string) to reduce chances of fatigue cracks in tubing and to stiffen the assembly immediately above drill collars.

Hydraulic requirements. Table 6 shows a thorough evaluation of hydraulics necessary to drill a 6¼-inch hole to a depth of 7,000 feet.

Table 7 is an evaluation of the pressure loss incurred when using 3½-inch and 2⅞-inch drill pipe to a depth of 7,000 feet. Both strings were used to drill a 6¼-inch hole while maintaining an annular velocity of 160-180 feet per minute.

TABLE 7—Pressure Loss in 3½-Inch and 2⅞-Inch Drill Pipe @ 7,000 Feet

Pressure Loss Through 3½-Inch Drill Pipe	Pressure Loss Through 2⅞-Inch Drill Pipe
67 psi per 1,000 feet or 469 psi at 7,000 feet	248 psi per 1,000 feet or 1,696 psi at 7,000 feet

From Table 7, it is evident that a string of 2⅞-inch drill pipe would not permit utilization of a sound hydraulic bit program below about 4,000 feet.

Rig and component equipment. Rigs assembled almost entirely on wheels or those using compact unitized

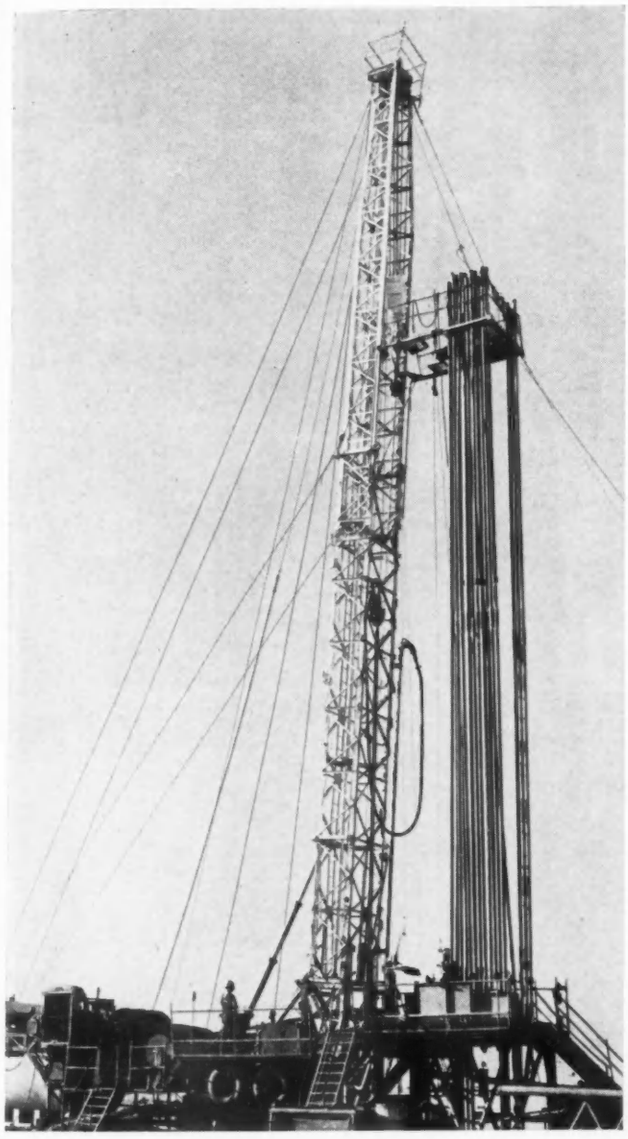


FIGURE 5—Trailer mounted slim hole drilling rig.

substructure and derrick which may be transported by truck are most adaptable to slim hole drilling.

Figure 5 shows a highly portable trailer mounted rig on wheels capable of drilling to 8,000 feet. Figure 6 shows a unitized rig which is moved by trucks and independently erected.

Portability, in addition to matching the horsepower and hydraulic requirements, is important in slim hole rig design. Weight of individual units should be minimized to permit travel over difficult terrain.

A diesel electric rig would satisfy portability requirements because individual units can be skid mounted and quickly dismantled and reassembled on the next location.

Pumps should be evaluated with hydraulic, surface and tubular equipment to maintain maximum hydraulic efficiency. Of course, the rig will be overpowered at minimum depths and underpowered at maximum depths. If possible, the rig should be operated in the medium depth range to take full advantage of available hydraulic horsepower.

It must be remembered that ability of tubing to transmit power to the bit is approximately one third that of 4½-inch OD Grade D drill pipe. An independently powered rotary table, therefore, is desirable to avoid application of excess torque.

In this case, a diesel-electric installation could compete economically with a straight mechanical drill split rig because one motor would drive both the drawworks and pump. Electric power would provide an ideal rotary table drive and would insure the degree of sensitivity required when tubing is used as drill pipe.

Bits. A study recently was made of 33 wells drilled between Eunice and Jal, N. M. This drilling was classified as medium hard to hard, with the average well requiring 10-14 bits. These wells were drilled in the Permian section, with the first medium hard bit run on the second or third bit under the surface. All wells were drilled with a jet bit program using water or natural mud. Table 8 shows results of the study.

TABLE 8

	Number of Wells Considered	Average Rate of Penetration Feet Per Hour	Average Feet Per Bit	Average Bit Cost Per Foot
6¼"	9	29.7	245	$.617
6¾"	12	28.4	344	.475
7⅞"	12	24.9	370	.513

The 6¼-inch bit had a slightly higher penetration rate than the 6¾-inch or 7⅞-inch bit. Although this condition existed, footage drilled per bit was 28% less for the 6¼-inch bit than for the 6¾-inch bit, and 33% less than the 7⅞-inch bit. This resulted in a 30% higher cost for the 6¼-inch bit than for the 6¾-inch bit.

The first well drilled required 154 total rotating hours. On succeeding wells, total rotating hours were 123, 115, 109, and 105, respectively.

Contrary to general opinion, it was found that bearings were not the weakest point in design of the 6¼-inch bit—in fact, little bearing damage was evident. The limiting factor was fast dulling of the teeth. High penetration rates were observed when bits were new, but rates dropped rapidly as the bit dulled.

In running a medium hard to hard bit, the average run of the 6¾-inch bit was 12 hours while the average 6¼-inch bit run was 8 hours. Bit weights varied from 4,000 to 4,500 pounds per inch of bit with rotary speeds from 60 to 100 rpm.

While drilling salt and anhydrite sections, the penetration rate of the 6¼-inch bit was good, and footage drilled per bit approached that of the 6¾-inch bit.

In subsequent drilling, longer bit runs are planned in soft to medium soft formations. The only green bits pulled were in soft sections. A good penetration rate was achieved in medium hard to hard formations, but no real progress was made in increasing the footage drilled per bit. However, no increase in footage drilled per bit was observed as penetration rates decreased.

As mentioned previously, there is a radical difference in footage drilled per bit between 6¼-inch and a 6¾-inch bit, but little or no difference between 6¾-inch and 7⅞-inch bits. Bearing failures have not been excessive,

and are not considered a problem. Tooth design on the same type bit is practically identical: tooth depth on 7⅞-inch bit is ½ inch; on a 6¾-inch bit, ⅜ inch; and on a 6¼-inch bit, 11/32-inch. The greater difference in groove depth occurs between the 6¾-inch and 7⅞-inch, not between the 6¼-inch and 6¾-inch bit.

Tooth width varies within the bit on each cone. Specifically, on the 3 cone, cutter row the width for the 7⅞-inch bit is 7/16 inch; for the 6¾-inch bit, ⅜ inch; for the 6¼-inch bit 5/16 inch.

With tooth design of equal hardness, footage for the three bits should be approximately the same if identical weight is carried per inch of bit. This condition exists between the 6¾-inch bit and the 7⅞-inch bit but the 6¼-inch bit will not perform in a like manner.

It is believed that application of the variable weight and rotary speed techniques could result in improved footage per bit performance. In other words, use less weight per inch of bit with higher rotary speeds on a new bit and, as the bit dulls, increase the weight and decrease rotary speed.

Fishing equipment. Modified conventional fishing equipment has been found satisfactory for slim hole requirements. A 5⅛-inch OD slim hole overshot, equipped with grapples to catch both 2⅞-inch OD tubing and 4⅛-inch OD tool joints, is normally used. The 4¾-inch OD drill collars can be retrieved by either a releasing spear or taper tap. Most fishing tools have a top connection of 2⅞-inch OD API flush box and special sub with a tubing tool joint "box up" and 2⅞-inch OD SPI, IF "pin down."

ACKNOWLEDGMENT

The authors wish to express their thanks to the operators, drilling contractors, service companies and manufacturers for their cooperation in providing information for Engineering Practices Report No. 4. A detailed reference list and acknowledgment will be included with the last installment of the series.

FIGURE 6—Compact, unitized slim hole rig designed for quick rig-up, rig-down, movement.

Remember . . .

Part 2 of this exclusive **Engineering Practices Report** No. 4 on small diameter well completions will appear in the September issue of your WORLD OIL. Included in next month's technical operating discussion will be information on primary cementing hookups for single and parallel string completions and primary cementing equipment.

Upgrade lower Minnelusa plays with lithofacies maps

Thorough regional mapping of rock types shows depositional environments, prospective areas

By William N. Zakis
Geologist, Continental Oil Company, Tripoli, Libya

DEFINING THE DEPOSITIONAL ENVIRONMENT OF THE LOWER MINNELUSA in adjacent areas of Wyoming, Nebraska, and South Dakota has provided new leads as to where to prospect. The structural approach is insufficient to do the job alone.

Critical carbonate permeability, generally absent insofar as pre-1960 known data are concerned, is the most vexing problem. A reconstruction of the depositional environment is required in order to upgrade one local area against another. The Powder River-Denver Basin Platform *(postulated herewith)* offers the best possibility for finding new lower Minnelusa oil.

The Minnelusa group is a recognized prospective rock sequence in the northwest part of the Denver Basin in Nebraska and Wyoming and the contiguous portion of the Powder River Basin in Wyoming and South Dakota. Major structural elements (Laramie Range, Black Hills and the buried Chadron Arch) exerted control over Minnelusa sedimentation. The Hartville Uplift is a Laramide feature and did not affect Minnelusa deposition.

Lower Minnelusa production has been limited to the Powder River Basin and to the Black Hills region (Figure 1).

Classification and definition. For oil exploration purposes it is expedient to subdivide the Minnelusa formation into two components, the lower and upper Minnelusa groups (Figure 2). Each group has recognizable boundaries and each is a workable unit for subsurface mapping purposes. The six-fold subdivision of Permian and Pennsylvanian rocks by Condra and Reed[1] with its subsequent revisions does not lend itself to subsurface mapping techniques because these divisions cannot be traced into the subsurface.

The boundary between the two groups is the "red shale marker," which is considered to mark the unconformity between the Missouri and Virgil series (Pennsylvanian, Figure 2). The line of section A-A′ on Figure 1 shows locations of the two wells used for the correlation chart. The age of the red shale marker is controversial since it has not been defined by fossil control.

The red shale marker is a buried residual soil present in the southeast Powder River Basin. It sweeps from the Hartville Uplift east to the Chadron Arch, and is found farther south of the Chadron Arch in the Nebraska Panhandle to the Nebraska-Colorado line. It is not recognized in the central and southern parts of the Denver Basin, nor is it found in the extreme northern and northwestern portions of the Powder River Basin (Foster[2]). Sand probably represents the red shale marker on the Laramie Range outcrops and the Black Hills. It is not distinguishable on the surface.

The base of the lower Minnelusa was placed at the top of the "Bell" (Fairbanks) sandstone, of undetermined age, but older than Atokan. The "Bell" sand was excluded from the lower Minnelusa group because it has formational status in its own right and is not considered to be prospective. Its inclusion in the group would inflate certain values of the various maps. Consequently, the lower Minnelusa group includes rocks of Missourian, Des Moines, and Atokan age.

Positive elements. Superimposed on the stable shelf were low-lying structural features that were (sporadically) mildly active, thus exerting some control over sedimentation. The Black Hills Uplift, Laramie Range, and the Chadron Arch are evident on all the maps. The Hartville Uplift was never a positive area during lower Minnelusa time.

The isopach map of the lower Minnelusa (Figure 3) shows that the least total section was deposited on these positive features while at the same time the most clastics and the most sand are found in association with these high areas (Figures 4 and 5). Little black shale is found on these highs, but comparatively thick accumulations are found on their flank

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This article has a dual purpose. The first is to evaluate oil and gas prospects of the lower Minnelusa (Pennsylvanian) formation in adjoining areas of Wyoming, Nebraska, and South Dakota.

The other is to show the modern trend toward complete analysis of an area or trend through preparation not only of structural contour maps, but also of facies maps showing types and quantities of sediments deposited, origin, depositional environments, possible reservoir and petroleum source rocks, and their relationships to one another. This complete type of presentation will continue to be developed and used by more geologists. It will also be studied, understood and accepted by an increasing number of management people regardless of the nature of their previous experience in oil operations.

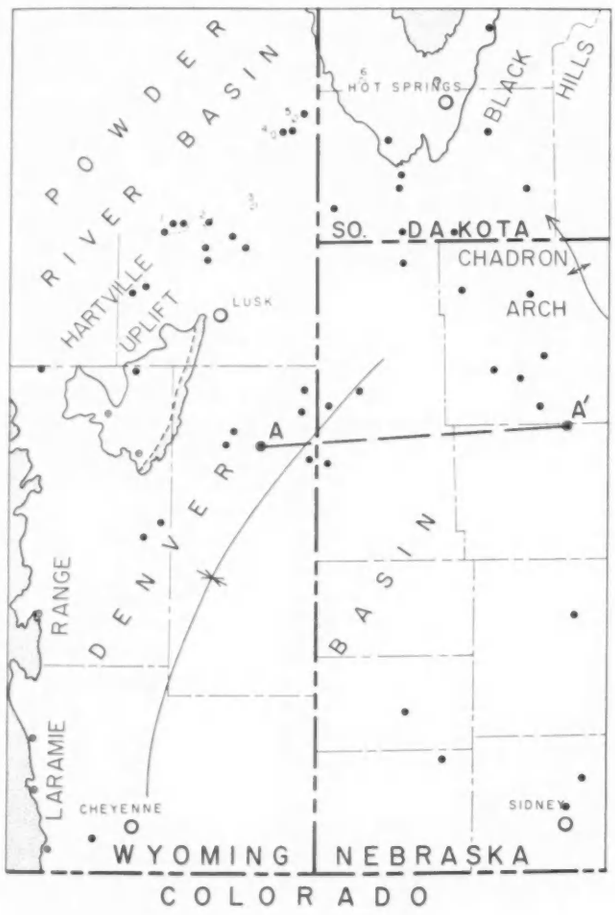

FIGURE 1—This index map (left) covers the area discussed in the text. Laramie Range, Black Hills, and Chadron Arch were structural elements exerting control over lower Minnelusa sedimentation. Hartville Uplift is of Laramide age, hence did not affect lower Minnelusa desposition. Commerical lower Minnelusa production has been obtained at Lance Creek (1) and East Lance Creek (2) fields in Niobrara County, Wyoming. Sub-commerical production has been found at Old Woman Anticline (3), West Mule Creek (4), Mule Creek (5) (also in Wyoming), and at Barker Dome field, South Dakota. Solid circles indicate well control. Crossed circles denote location of measured sections.

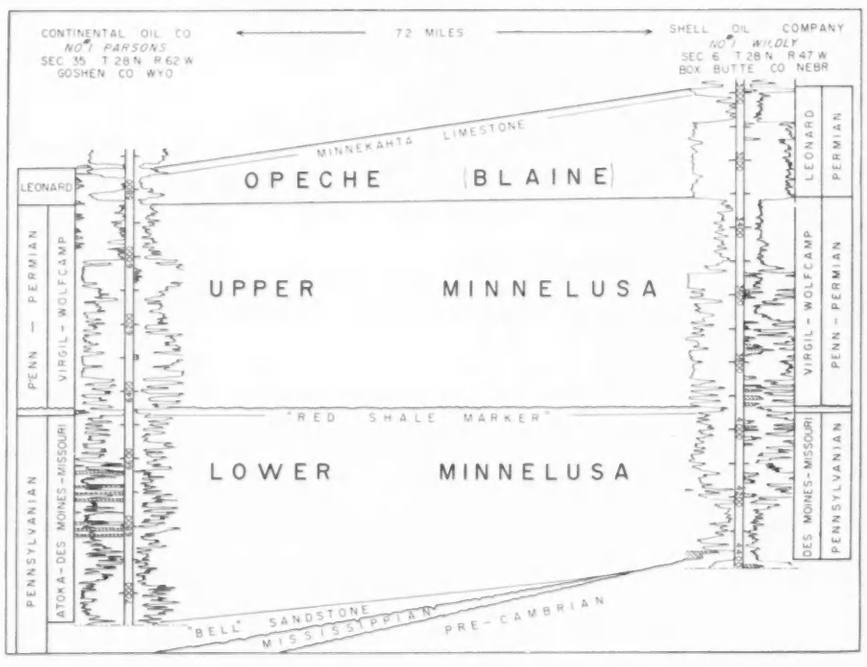

FIGURE 2—West-East cross-section and correlation chart from Goshen County, Wyo. to extreme northern Box Butte County, Nebraska. Lower and upper Minnelusa groups are convenient subsurface mapping units. Highly radioactive Des Moines black shales are easily recognized in samples and especially on radioactivity logs, in addition to the "red shale marker". Thick upper Minnelusa evaporites reflect conditions of deposition. Thick evaporites are not found in the lower Minnelusa.

areas (Figure 6). More dolomite also was deposited in the low areas than on crestal areas (Figure 7). Consequently, there is little doubt that these present structural elements, except for the Hartville Uplift, had their counterparts during lower Minnelusa time. The sites of each correspond closely, but lower Minnelusa structural elements were much more subdued compared to the pronounced features evident now.

Positive areas were dormant for long periods and clastic sediments thereon were reworked and redistributed. Negative epeirogenic movement then lowered the gentle highs into a marine environment so that the total section almost everywhere is a mixture of carbonates and clastics, with carbonates usually predominating (Figure 8). Only the Black Hills Uplift shows a clastic percentage of over 50 percent (Figure 5) and much of that is probably of marine origin.

Atokan sediments are found along the Laramie Range in varying thicknesses. Later redistribution of Atokan sediments may account in part for the variation in thickness. Gentle uplift pulsations of the Laramie Range caused a thinner section to be deposited, but with more clastics than in areas not affected by the uplift. During Des Moines and Missouri time the Laramie Range alternated between a low land mass and a marine environment so that the lower Minnelusa section there includes interbeds of limestone, sandstone and shale.

Depositional environment. The lower Minnelusa group was deposited on a relatively stable shelf under predominantly marine conditions. Lithologic components represented include limestone, dolomite, sandstone, variegated and black shales and anhydrite. Compared to the time involved, only

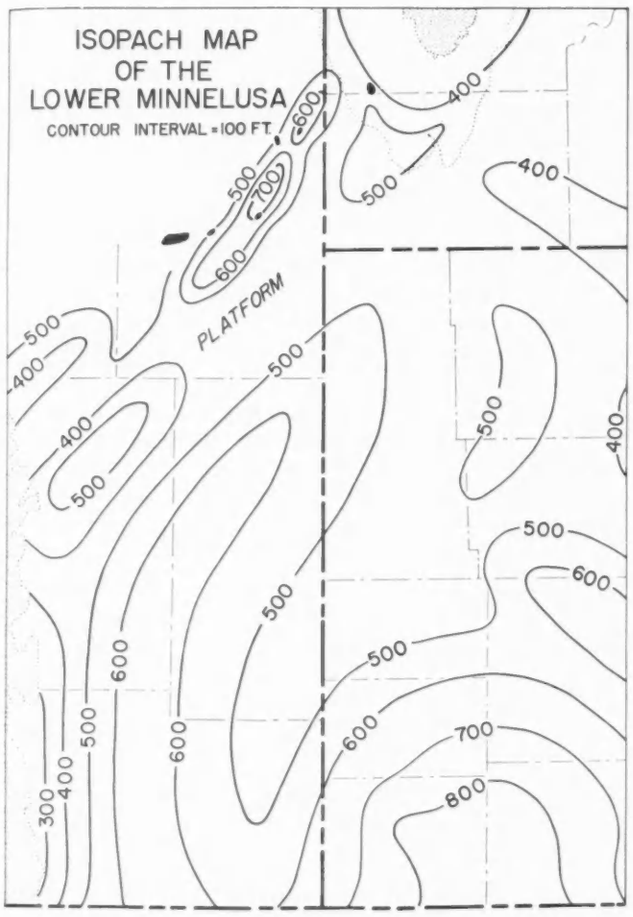

FIGURE 3—Isopach map of lower Minnelusa shows thin veneer of sediments deposited on relatively stable shelf. Thinnest section formed on high areas. Newly postulated Powder River-Denver Basin Platform is shown.

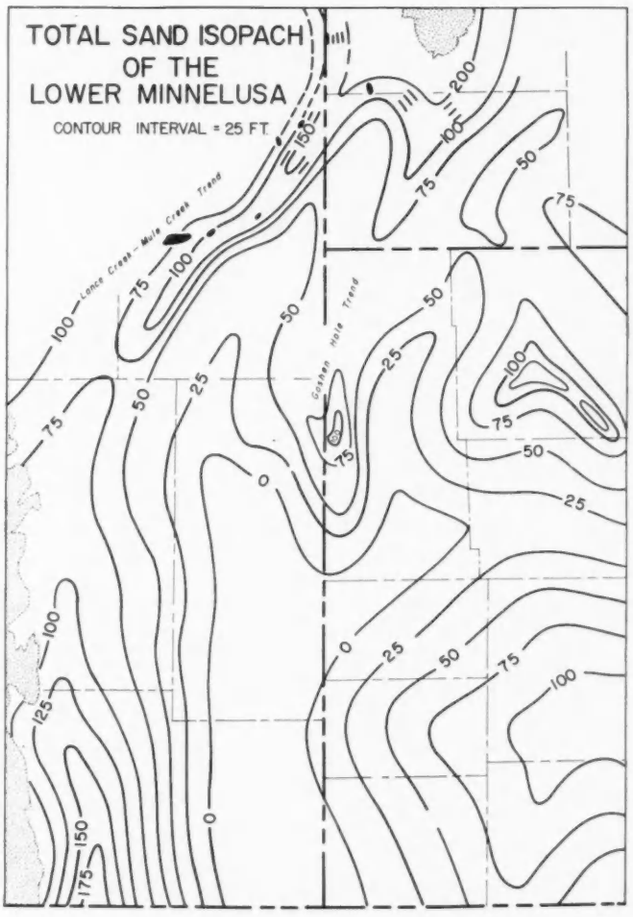

FIGURE 4—Total sand isopach of lower Minnelusa shows control of deposition by positive structural and topographic elements. Sand trends emanating from the Black Hills uplift are very pronounced.

a thin veneer of sediments (between 300 and 800 feet) was deposited (Figure 3). Variations in thickness are not extreme. This thin sedimentary section depicts a very low rate of sinking that must have been epeirogenic in nature, with the source areas far removed.

The seaway occupied the present site of the Denver Basin low (Figure 1), was open to the south, and was constricted periodically by the ancestral Front Range, Black Hills Uplift, and Chadron Arch portion of the Sioux Uplift. The Hartville Uplift occurred after Pennsylvania time. The deep part of the seaway is depicted on the clastic percentage map (Figure 5) by a decrease in clastic deposition, and on the sand and black shale isopach maps (Figures 4 and 6) by non-deposition of sand or black shale.

Restricted circulation of the seaway to the north is indicated in the lower Minnelusa by deposition of dark gray to black carbonaceous shale and by local accumulations of anhydrite. However, no true evaporite basin was formed in this area until upper Minnelusa time. Lower Minnelusa sediments differ markedly from upper Minnelusa strata in evaporite, dolomite, sand, and black shale content. The evaporite basin formed and extant in this area during upper Minnelusa time is characterized by *thick* deposits of anhydrite and red beds (not found in the lower Minnelusa). Also, no black shales are found in the upper Minnelusa group (Figure 2).

The character of sediments deposited during lower Minnelusa time is typical of (mildly) stable shelf areas. Limestones are marine, clean, gray, fine to very finely crystalline, and dense. Some chalky limestones indicate a shallow sea. Limestones frequently become dolomitized, and chert is fairly common. The limestones are thicker and more widespread than the sandstones.

No blanket-type sands were deposited during the lower Minnelusa. Instead the sands are thin, disconnected, were moved from place to place, and finally became localized close to the high areas.

Des Moines-age conglomerates were deposited on granite on the Chadron Arch. These conglomerates are essentially non-arkosic, indicating that the granite core of the Chadron Arch was never long exposed, and that the conglomerates were probably derived from the higher Sioux Uplift to the east.

Lower Minnelusa shales vary from true marine gray and gray-green, to the red, brown, and black of near marine conditions. Anhydrite is present in most wells, but seldom exceeds 10 percent of the net section.

In this low-lying area occupied by a shallow sea, minor epeirogenic movement resulted in rapid transgression and regression. Vertical changes in lithology occurred without transition from one rock type to another, as limestone to sand, or shale to limestone. Consequently many local unconformities are present, as well as

the regional unconformities between different Pennsylvanian series.

Depositional trends. The Black Hills Uplift was a positive element which exerted control over sedimentation in its vicinity, as evidenced by two pronounced sand trends which emanate from this uplift. These two trends (Lance Creek-Mule Creek, and Goshen Hole), are most evident on the total sand isopach map (Figure 4). The Goshen Hole Trend in northeast Goshen County, Wyoming, and adjacent Sioux County, Nebraska, coincides with the Goshen Hole physiographic depression. Both trends are evident on all of the geological maps.

All production from the lower Minnelusa in the southeast portion of the Powder River Basin is located on the Lance Creek-Mule Creek trend. In the Denver Basin, the only good oil shows found have been associated with the Goshen Hole trend in fractured, dense dolomites; production in the Lance Creek-Mule Creek trend has been mainly from the so-called "Leo sand" reservoirs. There is more than one "Leo sand"; none of them extend into the Denver Basin. Individual sand beds in the Powder River Basin do not correlate with the sand beds in the Denver Basin, although they fall in the same Des Moines section of the lower Minnelusa.

The Goshen Hole trend is considered anomolous because, although centrally located and far removed from the positive area, sediments deposited there are similar to those deposited on the flanks of the highs. In fact, this area lies directly in the path of the open seaway to the south, yet its sand, black shale, and dolomite content are as high, or higher, than any in this region. On the isopach map (Figure 3), the Goshen Hole trend has a slightly thicker section than the present Hartville Uplift to the west. The clastic percentage of the Goshen Hole trend, up to 40 percent is also high (Figure 5).

These stratigraphic conditions in the Goshen Hole trend are very similar to those observed in the Lance Creek-Mule Creek trend. These trends may represent deposition on opposite flanks of a weak, submerged platform which is here postulated and named the Powder River-Denver Basin Platform (Figures 3 and 5). It is believed that this submerged land bridge connected the Laramie Range and the Black Hills Uplift during lower Minnelusa time. As such, the platform separated the incipient Powder River and Denver basins.

Based on some evidence of a thinner lower Minnelusa section, the location of this platform is placed north of the Hartville Uplift and thence connects with the Black Hills and the Laramie Range. Limited control indicates a thinner section on the platform than exists on the Lance Creek-Mule Creek trend to the northwest or on the Goshen Hole trend to the southeast.

The importance of the platform is in the character of the sediments de-

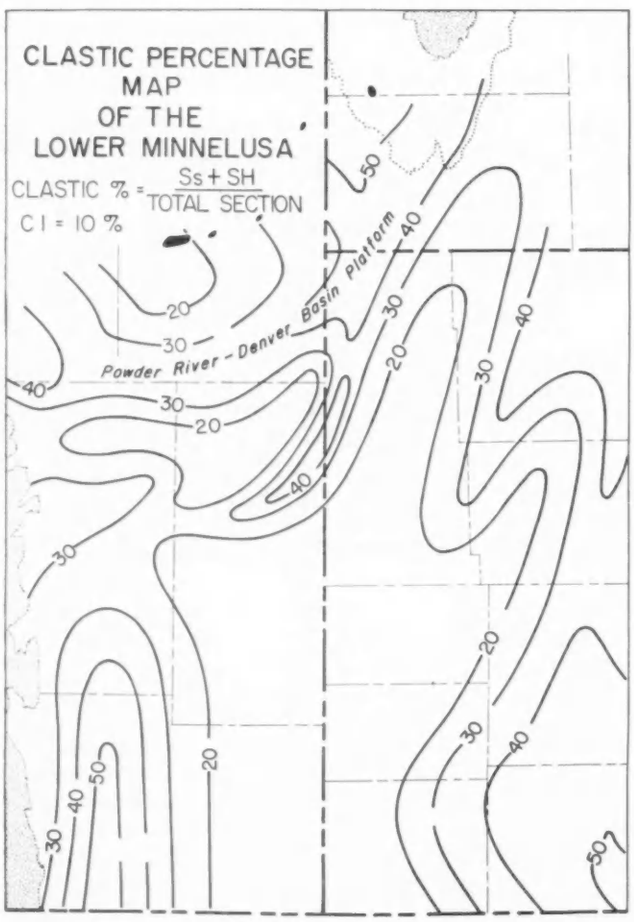

FIGURE 5—Clastics percentage map of lower Minnelusa shows relationship of clastics to positive features. Goshen Hole trend has high clastics percentage.

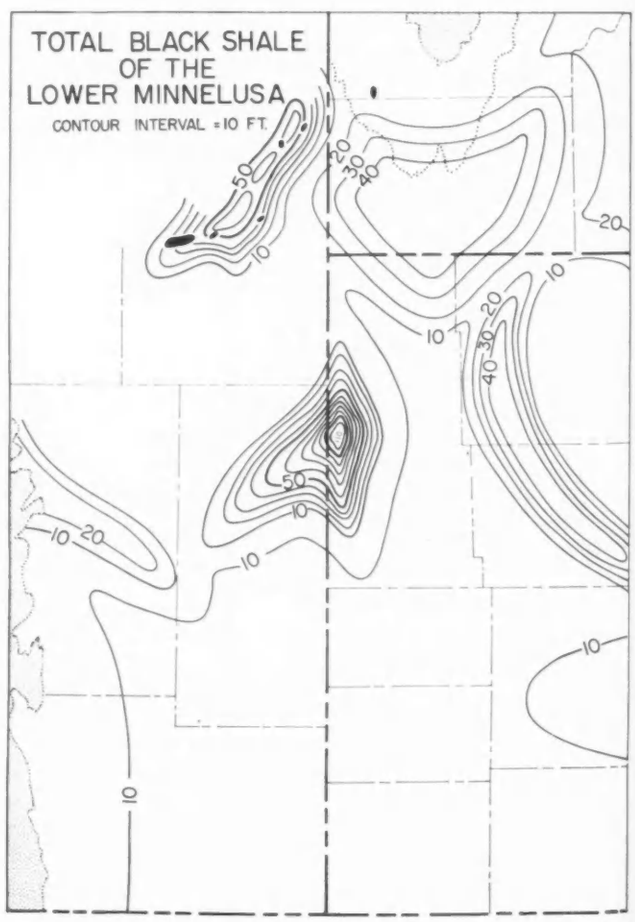

FIGURE 6—Black shale deposition was due to restricted circulation in localities adjacent to high areas. Little or no black shale is found on the crests of highs.

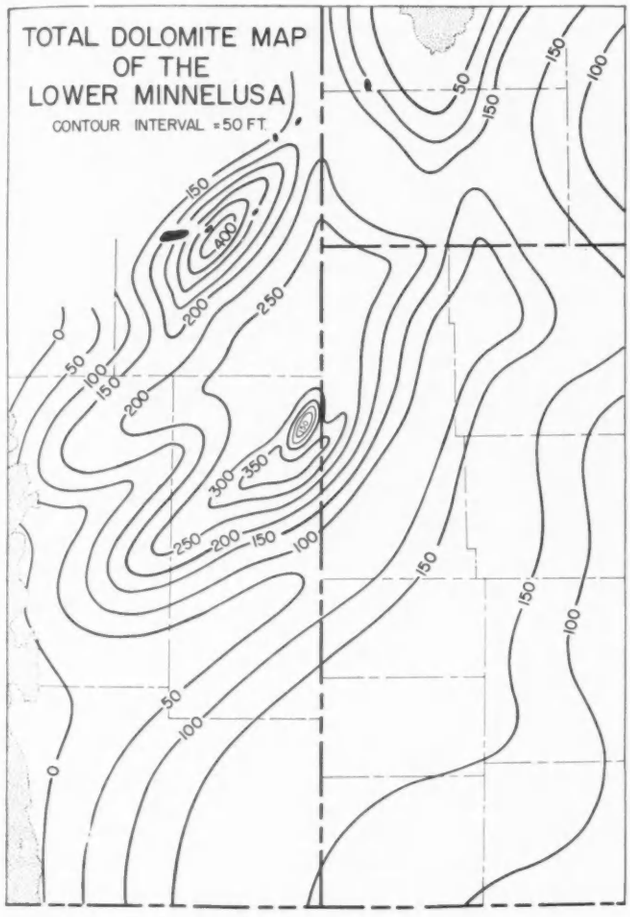

FIGURE 7—Total dolomite map of lower Minnelusa shows predominance of dolomite deposition in Lance Creek-Mule Creek and Goshen Hole trends. Parallel nature of Lance Creek-Mule Creek and Goshen Hole trends and Powder River-Denver Basin Platform is rather evident in this figure.

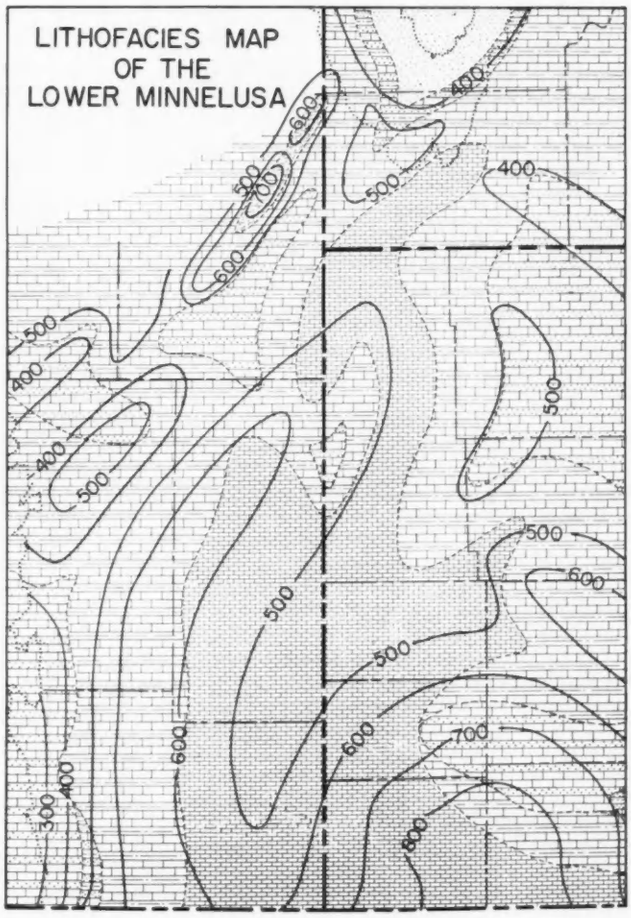

FIGURE 8—Lithofacies map of lower Minnelusa shows the marine character of sediments, with carbonates predominating. Positive elements are indicated by introduction of sand into carbonate sequence. Intermediate (flank) areas show mixture of sand, carbonates, and shale. Open seaway is indicated by complete carbonate deposition.

posited there. Being close to or above wave base, sands would be reworked, sorted, cleaned, and concentrated. Limestones and dolomites could undergo the same process and give rise to fragmental carbonates. A black shale-dolomite association located on the flanks of the platform would be of especial interest. In more protected areas, *growth of bioherms* would be stimulated, since ideal conditions for reef growth exists on such platforms.

Lithofacies map. Depositional environment, sedimentation and structural grain of this area during lower Minnelusa time is shown on the lithofacies map (Figure 8). This is a composite picture of total sedimentation at the end of lower Minnelusa time, not a picture showing any particular instant of that epoch.

The lithofacies maps show the following.

- The environment of deposition was marine.
- The thin veneer of lower Minnelusa sediments, between 300 and 800 feet, attests to the long period of stability of the regional shelf, of which this area is but a small part.
- Positive elements which exerted control over sedimentation are characterized by variations in lithologic components.
- These elements periodically constricted the seaway which was open to the south, and were themselves local source areas.

Figure 8 thus illustrates the marine character of lower Minnelusa sediments, while at the same time emphasizing the high areas from the intermediate or low areas.

Such a lithofacies map can be used to upgrade one local area against another, and is the basic objective of this study. The Powder River-Denver Basin Platform offers the best Minnelusa prospects. This platform, together with the depositional trends associated with its flanks, constitute the best ancient environment for production. Here is found a suitable mixture of marine sediments necessary for the formation of source and reservoir rocks. Drilling depths are not excessive—the entire lower Minnelusa section can be effectively tested with 4,500 to 7,000 foot holes.

Areas where the rocks are entirely limestone or sandstone can be discounted, for the limestones of the open seaway are dense, while the thick sandstones of of the Black Hills have been affectively flushed.

The Chadron Arch is not considered as prospective, since most of the sands there are concentrated toward the base and lie on granite, and the

carbonates are tight. More red shales are also found associated with the sands on the Chadron Arch, the Black Hills, and the east flank of the Laramie Range than elsewhere. Economic reasons alone are enough to dispel the east flank of the Laramie Range from serious consideration. There, close to the axis of the Denver Basin, drilling depths through the lower Minnelusa exceed 10,000 feet. Coupled to this deterrent is the fact that the section there is thin, with little possibility of encountering source or reservoir rocks.

ACKNOWLEDGMENT

The author is indebted to John Strickland, a division geologist with Continental Oil Company, for certain measured sections (circled crosses on index map, Figure 1). Other measured sections incorporated in this article are those of Love,[3] Bates,[4] and Agatston.[5]

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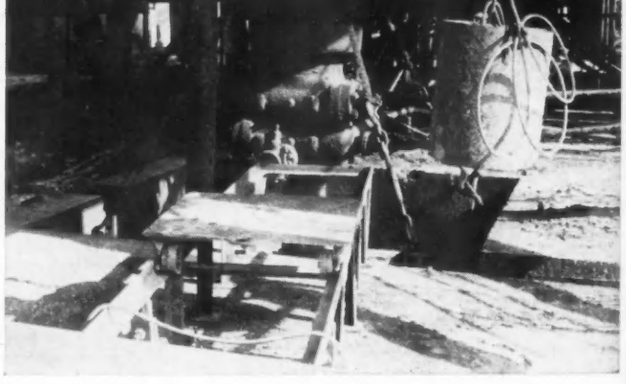
1 . . . 2 . . . 3 . . . Hike!

Pigskin Plug Stops Pulsations

Electrically driven pumps operating in a waterflood project at 900 psi pressure caused severe vibrations in welded joints and connections. Obviously, an economical vibration dampener was required to prevent breakage of lines. To solve the problem, a plastic covered football was placed into the 7-inch suction spool shown in the photograph. The ball compresses and expands with pump action and its-tough covering prevents bursting. Since the ball was installed, the pump has operated vibration-free.

Trolley Removes Blowout Preventer



Blowout preventers are large and cumbersome to handle. A trolley made of old used bit cones and angle iron has minimized this existing problem. The bit cones are cut off the shanks of a worn out bit. Then 4½-inch drill pipe is aligned and welded on the cone of the bit making a wheel. The pipe and cones are then welded in position on the bottom of a ½-inch plate and the entire platform can be easily wheeled into position by one man for either removing or installing the blowout preventer.

For other time and money-saving Hints, turn to pages 26 and 76 of this issue

About the Author

William N. Zakis was born in Hanna, Wyo. and received B.S. and M.A. degrees in Geology from the University of Wyoming in 1949 and 1950. Since 1950, he has been employed by Continental Oil Co. During 1950-1953, he was engaged in field work in the Four Corners area while based in Durango, Colo. In September 1953, he was transferred to Casper, Wyo., where he filled the position of district geologist until September 1955, when he was transferred to Denver, Colo. In Denver he was primarily concerned wtih subsurface studies. In April 1960, Zakis obtained a temporary two-year transfer to work for Oasis Oil Company, partly owned by Continental Oil Company, in Tripoli, Libya.

How downhole rubber liners can help YOU

New tool protects productive intervals from fluid loss damage during well stimulation treatments, permits selective frac, acid and squeeze jobs

By George L. Gore
President, Select Services Company, Denver

A NEW TEMPORARY downhole liner consisting of a length of large diameter rubber hose is being used to seal off perforations or permeable zones during well stimulation treatments. The liner prevents fluid loss from wellbore to formation and is easily retrieved from the hole after associated work (fracturing, acidizing, etc.) has been completed. Liners are constructed for 5½-inch and 7-inch casing in lengths from 10 to 50 feet.

The liner is constructed of four-ply, nylon cord-reinforced neoprene hose, and is slightly larger in diameter than the casing or hole in which it is used. For example, 5⅜-inch OD liners are used in 5½-inch OD casing (pipe ID may vary from 4.670 inches to 5.012 inches, depending on weight). However, ends are tapered to a smaller diameter (4$^{9}/_{16}$-inches for 5⅜-inch hose) to receive a short, drillable brass sleeve. The sleeve is riveted into either end for gripping and stretching purposes.

Operation of the liner is based on the principle that lengthwise stretching of a hose will reduce the diameter. When tension is released and the hose returns to its original length, original diameter is restored. Since OD of the hose is greater than the ID of the casing, a tight pressure fit is obtained and fluid flow from wellbore to formation is prevented (Figure 1).

Preliminary testing. Tests have shown that the liner is rugged and will stand considerable abuse without failure. Figure 2 shows the stretching characteristics of the neoprene hose, plotting tension versus length. Figure 3 shows the characteristic reduction in diameter of the hose under different amounts of tension. All tests were made by applying load with a hoist and measuring the tension with a dynamometer. Curves are shown for both increasing and decreasing loads.

Other tests were conducted in which a liner was set in a 10-foot section of 5½-inch casing, equipped with nine ½-inch drilled holes. Pumping rates as high as 30 bpm through the liner produced a maximum pressure drop of 15 psi through the liner. No movement of the liner in the casing was apparent. On other tests, internal pressures up to 4,500 psi, at a pump-through of 6-8 bpm, produced no leaks and failed to damage the hose.

The same test conducted in blank pipe resulted in some movement of

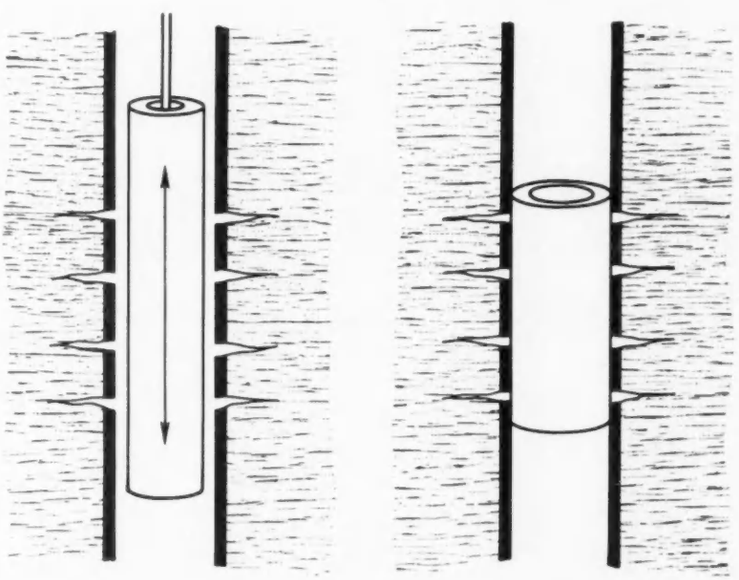


FIGURE 1—New temporary liner operates as shown here. A large diameter rubber hose is stretched to reduce its cross-sectional area, and is positioned opposite the perforations. When released, the liner tends to return to its original diameter which is slightly larger than the casing string in which it is set. Thus, the liner seats against the walls of the pipe and a tight pressure fit is obtained.

the liner, indicating that a differential pressure across the hose is necessary to lock the liner in place.

Case histories. Following are several examples of jobs recently performed in the Rocky Mountain area.

Gas Well, The Ohio Oil Company, Cheyenne County, Nebraska.

This well, with 20 feet of open perforations, began making water and an attempt was made to seal off the bottom 5 feet with cement without damaging the upper 15 feet of pay. A rubber liner was run and set in place, to cover the upper 15 feet of perforations.

The setting assembly was removed, and a cement retainer was run on tubing and set above the liner. A conventional cement squeeze was performed, leaving cement in the casing and liner below the retainer. Initial squeeze pressure was 2,600 psi, with a final pressure of 3,000 psi. Cement was allowed to set and the upper section was drilled out and reperforated for dry gas production without the aid of any other stimulation work, indicating the successful exclusion of cement from the pay zone.

Normally, although some cutting of the surface rubber occurs at high pressures causing partial extrusion into the perforations, the hose does not rupture. Thus, when the liner is withdrawn from the hole, the cut rubber remains bonded to the liner, clearing the perforations. Because of the drilling out operation, the extruded rubber was sheared off on the job described previously and the perforations were plugged. Thus, a reperforating job was necessary.

Gas Well, American Climax Petroleum Corporation, Mesa County, Colorado.

Well was perforated in Dakota at 2,970-3,006 and in Morrison at 3,372-3,379. Because of very low bottom hole pressure in the Dakota, it was necessary to blank off this zone prior to fracturing the Morrison.

A 40-foot liner was stretched and lowered into the hole. Collars were checked with a sonic collar locator, and the liner was released to cover the perforations 2,970-3,006 feet. One truck was used to break down the lower zone. A spinner survey was run to check the liner and indicated no loss of fluid through the covered interval. The well was fractured at a maximum rate of 22 bpm down the casing at a maximum 3,000 psi (total frac-42,000 gal. diesel, 30,000 pounds sand).

A retrieving attachment was run on sand line and the liner was dragged from the hole at approximately 150 feet per minute. Inspection showed impressions of the perforations but no cuts. The liner was suitable for use on another job.

Gas Well, British American Oil Producing Company, Kimball County, Nebraska.

Well was originally completed in two intervals with a third possibility between the proven zones. A bridge plug was used to isolate the lowermost zone and the middle interval was opened for production. Since only 10 feet separated the upper and middle zones, and there was a possibility of communication behind the pipe, operator did not wish to risk a possible stuck packer.

A 25-foot rubber liner was used to blank-off the upper zone and the well was fractured successfully. The liner was retrieved on sand line, and perforation impressions confirmed proper placement and effectiveness of the job.

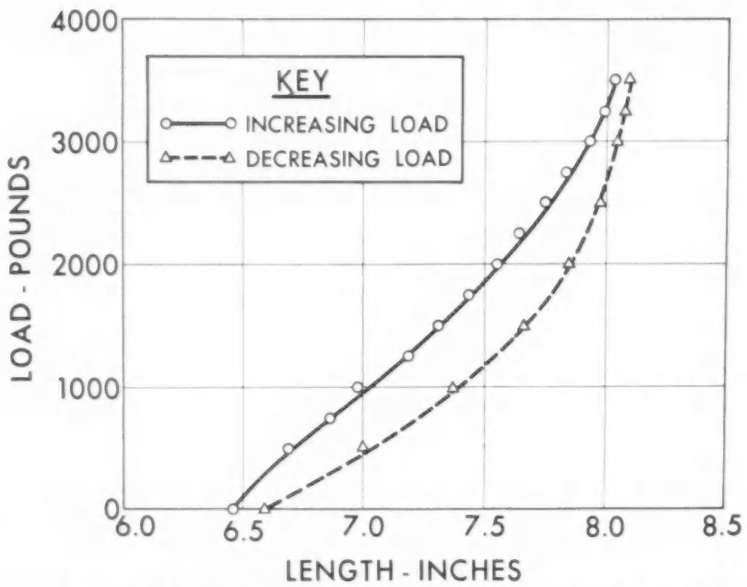


FIGURE 2—Load tests indicate stretching properties of the liner. As indicated, the hose stretches approximately ½-inch per 1,000 pounds of applied load.

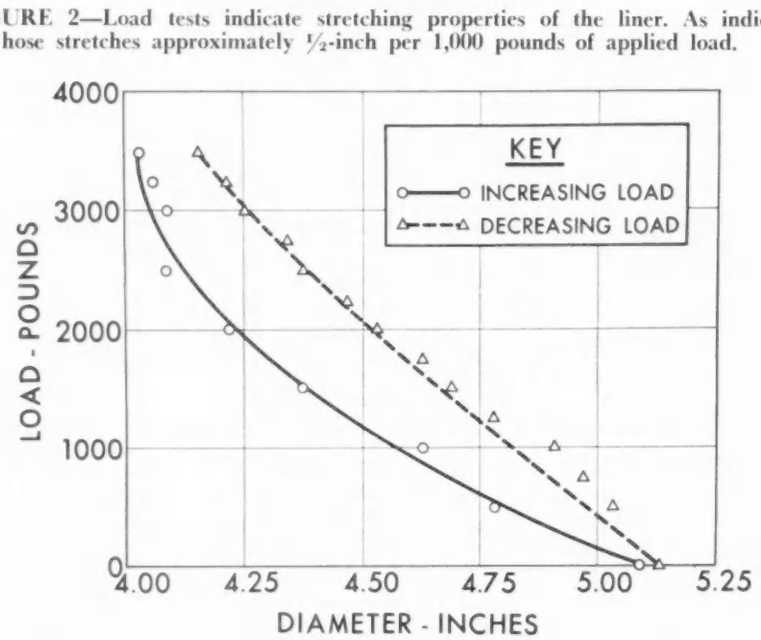


FIGURE 3—By applying 3,000 pounds tensile load, liner diameter is reduced approximately one-inch. This provides the basic principle of operation of the tool since liners larger in OD than the ID of the receiving casing string can be used. As indicated in Figure 1, the liner attempts to return to its original diameter when released, thus providing a tight seal.

Operating procedure. In operation, a special hydraulic setting-

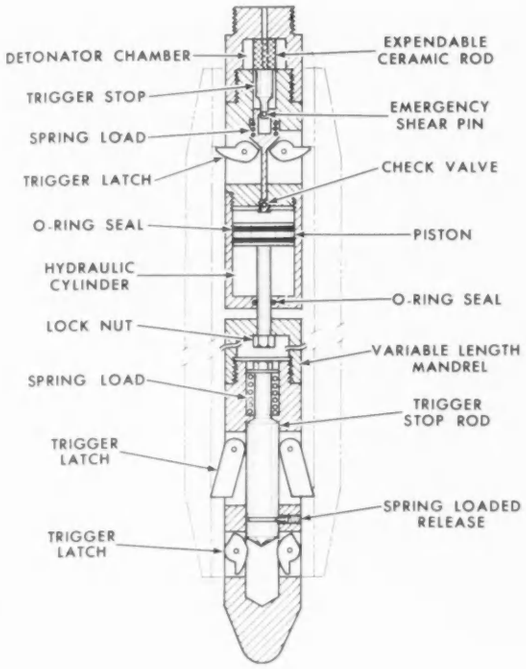


FIGURE 4—Hydraulic setting-retrieving tool is used to position the liner in the hole or remove it after work has been completed. A sonic collar locator is used to assure proper depth correlation.

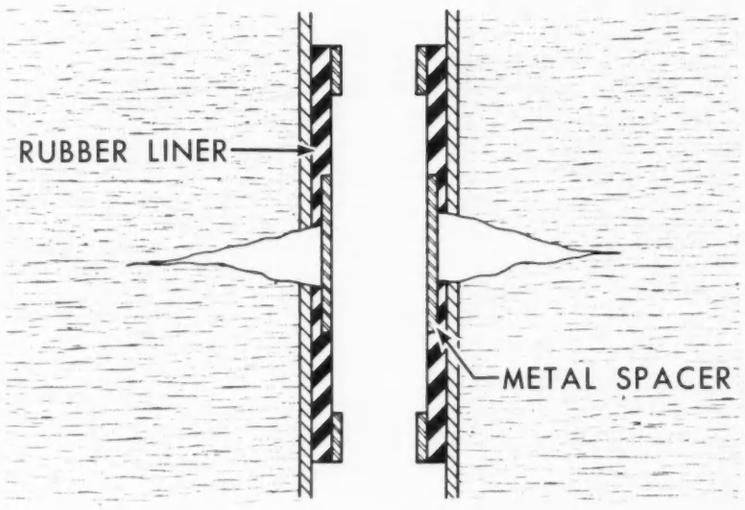


FIGURE 5—Modified rubber liner is used if casing notch is to be blanked off. Metal sleeve prevents liner from extruding into notch.

stretching tool (Figure 4) is first inserted in the liner. This tool is adjustable to any length liner and has trigger latches at each end that engage with the brass inserts at either end of the liner. The tool is stretched by hooking onto a gripping bridle and applying tension by means of a winch. When locked in its extended condition, the liner, together with the setting tool, is lowered to the desired depth in the well on wireline. A sonic collar locator is used for proper positioning.

A blasting cap then is detonated electrically, destroying the ceramic rod at the top of the setting tool and releasing the upper trigger latches when the trigger stop moves upward. The tool then can be withdrawn from the released liner and the well.

Application of additional internal pressure, such as increased hydrostatic pressure, or that applied from the surface during an acidizing or fracturing operation, holds the liner more securely in place, increasing effectiveness of the seal.

In retrieving the liner, the tool is lowered into the well on wireline with the spring-loaded rod sealing off the hydraulic cylinder from well pressure. Thus, the tool is in its shortest condition.

The bottom foot is lowered through the liner and picked up, causing the lower trigger latches to catch and hold the bottom of the liner. A strain of about 200 pounds releases the lower trigger stop rod, which in turn releases the lower trigger latches and sets those just above. Meanwhile, the upper trigger latches engage the brass insert at the other end of the liner, and the tool is in place.

An upward strain on the line overcomes the spring-load of the upper rod, unsealing the hydraulic cylinder and allowing well fluids to enter. Due to the O-ring seals, well pressure cannot act on the bottom of the traveling piston. The hydraulic pressure of the fluid in the well bore acts downward on the large-diameter piston and upward on the traveling rod which is of smaller diameter. The result is a net downward force, which lengthens the setting tool.

As the upper and lower trigger latches meet their respective brass adapters, the rubber liner is extended. As it stretches, diameter is reduced and it is free to move up or down the casing, or out of the hole. The check valve traps well fluid in the hydraulic chamber so that the tool does not shorten until it has been pulled from the well.

If a liner is to be set at a new depth, it is positioned and electrically

About the Author

George L. Gore was graduated from Oklahoma A. & M. College in 1949 with a B.S. degree in electrical engineering. He joined Dowell following graduation and worked as both service engineer and district engineer in the Rocky Mountain area. He organized Select Services in 1957 and now serves as chief officer of the company.

released as described previously. If a restriction occurs up the hole (such as a swage pipe or tandem liner which prevents the retrieving tool from functioning properly so that it cannot be released from the liner), sufficient strain is taken on the line to rupture the shear pin. This safety feature releases the liner so that the assembly may be withdrawn to correct the difficulty.

Removal of shorter length liners does not require elongation with a retrieving tool. The liner can be removed by the latching tool with a pull of about 1,700 pounds on the wireline.

Field testing. Versatility of the liner makes it a valuable aid in solving many production and workover problems. Typical conditions under which it may prove beneficial include:

- Isolating thief zones in waterflood injection wells.

- Selectively acidizing or fracturing specific sections of long perforated intervals, or multiple zone wells.

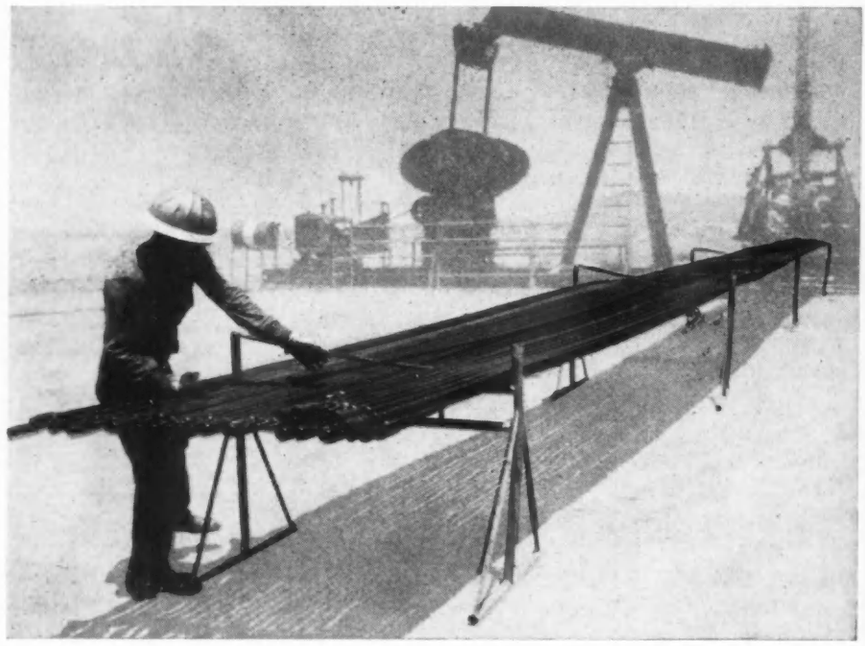
- Selectively squeeze cementing multiple zone wells.

- Blocking old perforated intervals above zones to be stimulated to prevent sticking pipe and retainer because of channeling behind casing. If liner is used, tools can be positioned above uppermost zone or job can be performed down the casing.

- Sealing previously induced casing notches when additional notches and fracture jobs are to be performed. The modified liner shown in Figure 5 is used in these cases.

In the above applications, it will be noted that the problems involve one common factor—the necessity of sealing one or more intervals before pumping into another zone. There are probably other conditions under which the tool would prove helpful.

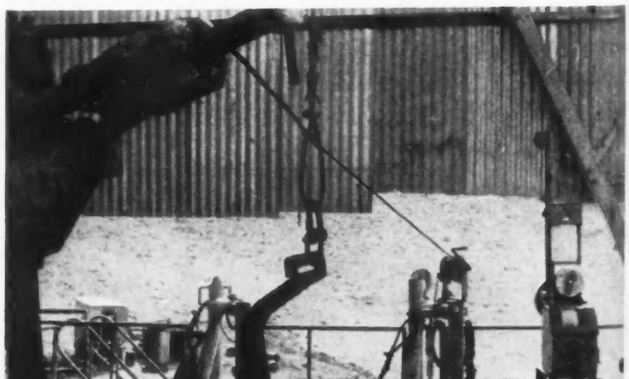
Future developments will be aimed toward perfecting a modification of the device which will hold back differential pressure external to the well bore. Preliminary tests have shown that pressures up to 1,100 psi can be retained successfully before leakage past the sealing element occurs. **—The End**



Rack Helps Ease Rod Tailing Job

A convenient rack for sucker rods may be made from junk rods and scrap pipe. One and one-half-inch pipe is used for the cross members of each "horse" and side posts and braces are made from the sucker rod material. As shown, the strip that separates each layer is laid on top of the post on the "tailer's" side and rods are easily skidded into place in neat rows. When a row is complete, strippers are removed from the tops of the posts and new ones are installed.

Kelly Handling Made Easier



The hand-operated winch is used to pull the kelly adaptor, swivel and hose out of way when making connections or trips. The winch is mounted on the back up post as shown. A ¼-inch cable is used with a hook that fits the adaptor on the kelly. One man winds up the cable freeing the remainder of the crew for other necessary operations. After the kelly is positioned out of the way, a small bolt is placed in one of the holes provided to hold the winch until the connection or trip is made.

Did you miss the other time and money-saving Hints on pages 26 and 72 of this issue?

Can WOC time be reduced?

Laboratory and field data results show 4-8 hours time lapse sufficient to develop adequate cement strength

By William G. Bearden,
Research Technical Group Leader and
Robert D. Lane, Senior Petroleum Engineer,
Pan American Petroleum Corporation, Tulsa

PREVIOUS DATA AVAILABLE to the petroleum industry have shown that relatively low-strength cement is capable of supporting the casing in oil wells. Recent developments in which the casing-supporting ability of cement is evaluated under simulated bottom-hole temperature and pressure conditions show that by proper selection of cement, "waiting-on-cement" (WOC) times may be reduced to the order of 4 to 8 hours. Under such conditions the time required to perform the necessary rig operations, becomes the limiting factor; therefore, revised rig operations to eliminate nonproductive time are suggested.

In an effort to reduce the resulting nonproductive rig time, a comprehensive labortatory and field study was initiated to:

- Re-establish the minimum strength requirements of cements in oil wells.
- Determine at what time minimum strengths of cementing systems currently being utilized were obtained under simulated well conditions.
- Formulate a revised WOC time policy based on these evaluations. Heretofore, regulatory bodies have required WOC time of 24 hours or more; however, because of recent advancements in cementing technology and practices, this time interval has been reduced to less than the 24 hour waiting period.
- Revise cementing and rig operations to take maximum advantage of the reduced WOC times.

STRENGTH REQUIREMENTS OF CEMENTS

Laboratory tests of casing supporting ability. To investigate the strength requirements of cements, a series of tests were performed in which the casing supporting ability of an annular ring of cement was determined. Among the variables considered were diameter and length of pipe, type of cement, tensile strength of the cement and the wetted condition of the pipe.

These observations were made on cements cured in the annulus between two pipes ranging from 1.3 inches to 8.625 inches OD and from 4-inches to 16 inches in length. Several types of cements were included and observations were made at tensile strengths ranging from 4 to approximately 300 psi. Figure 1 presents a schematic view of the specimen used in this series of tests.

In performing the tests, the cements were poured into the specimens shown on Figure 1 and into conventional tensile-strength briquette molds. After curing under water for a specified length of time, the ability of the cement to support the casing was determined by observing the force required to move the inner pipe with respect to the cement. This force was termed the "force to break the cement bond." To aid in correlating results, the force to break the cement bond was divided by the area of the casing contacted by the cement (the area over which slippage occurs) to determine the cement "support coefficient" in pounds per square inch. Tensile strengths were determined by means of the briquette specimens.

Effect of casing diameter and length. The effect of casing diameter and length on the ability of cement to support casing was determined by a series of six tests utilizing specimens as shown on Figure 1. A neat API Class A cement and Class C cement were used in these tests. The dimensions of the specimens used and the resulting support coefficients are shown on Table 1.

The effect of casing diameter is illustrated in Tests 1, 2 and 3 of Table 1. It was observed that at any constant strength of cement, the force to break the cement bond increased with increasing diameters of the inner casing (dimension A, Figure 1). It may be noted, however, that regardless of the casing diameter, the force required to break the bond divided by the surface area of the casing contacting the cement (the support coefficient) is relatively constant.

The effect of casing length is illustrated in Tests 4, 5

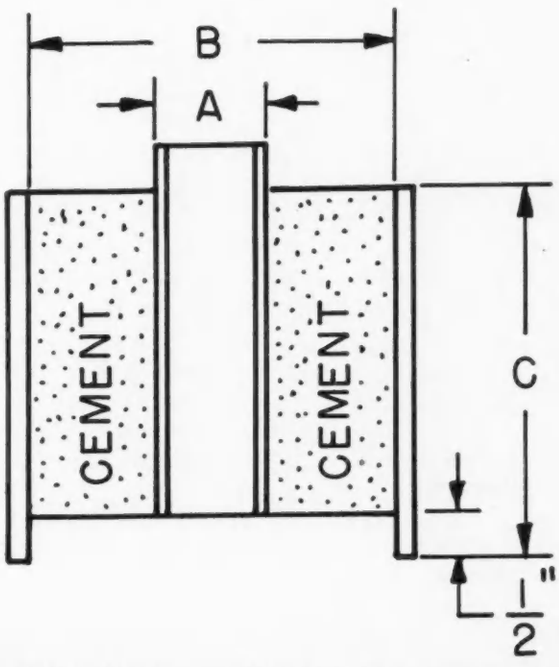


FIGURE 1—Specimen used to determine cement support coefficient.

TABLE 1—Effect of Casing Diameter and Length on Support Coefficient

Test No.	API Class of Cement	Tensile Strength, psi	CASING SIZE			Force to Break The Cement Bond, lbs.	Support Coefficient psi
			OD of Inside Pipe, in. (A)*	ID of Outside Pipe, in (B)*	Length, in. (C)*		
1	A	18	1.301	2.05	4	196	13.7
			2.375	3.50	4	381	14.6
			5.5	8.00	4	907	15.0
2	A	33	1.301	2.05	4	580	40.5
			2.375	3.50	4	1,160	44.4
			5.5	8.00	4	2,805	46.4
3	A	75	1.301	2.05	4	1,320	92.3
			2.375	3.50	4	2,920	112
			5.5	8.00	4	6,225	103
4	C	7	2.375	4.89	4	131	5.0
			2.375	4.89	8	199	3.6
			2.375	4.89	16	843	7.3
5	C	28	2.375	4.89	4	640	24.5
			2.375	4.89	8	1,690	30.2
			2.375	4.89	16	3,810	32.9
6	C	71	2.375	4.89	4	3,800	146
			2.375	4.89	8	5,860	105
			2.375	4.89	16	12,925	112

* See Figure 1.

and 6 of Table 1. It may be noted that for any cement strength, the force to break the cement bond is increased with increasing casing length (dimension C, Figure 1). Again, the support coefficient is relatively constant.

Effective of type and strength of cement. The results of tests to determine the effect of the type and strength of cement on the ability of the cement to support casing are listed on Table 2 and plotted on Figure 2. All tests shown were performed on at least 3 sizes of specimens shown on Table 1. The support coefficients are the average values observed.

From these data, it may be concluded that the ability of a cement to support the weight of casing increases proportionally to the tensile strength of the cement. It is also evident that there are no large differences between the types of cements. Figure 2 shows that the two cements exhibiting the highest support co-efficients were an API Class C and a special low-density cement (Special cement A). Both types are finely ground. This suggests that the finer the grind, the closer the cement will adhere to minute irregularities on the surface of the casing, thereby increasing the surface area in contact.

It is interesting to note that two cement compositions which reportedly possess improved bonding to steel (Class A cement plus a latex emulsion and the oxychloride cement exhibited no higher support coefficient for the corresponding tensile strengths than did the neat API Class A cement.

The tests of the kerosene-emulsion cement (Test 23, 24 and 25 of Table 2) were included to determine if the presence of a hydrocarbon in the cement would make the casing oil-wet, and thereby decrease the bond between the casing and the cement. Test results indicate that although the casing appeared oil-wet, the support coefficients were not appreciably lower than those observed with the other cements.

Effect of mud on the casing supporting ability. Three series of tests were performed to determine the effect of the presence of mud on the casing support coefficient. In all tests the inner pipe was allowed to stand in a bentonite water-base mud for one hour. In the first series of tests, the inner pipe was removed from the mud, a cement slurry was flowed past the pipe at velocities simulating those encountered in the field, and the pipe was placed in the outer pipe as shown in Figure 1. A Class A cement was then poured into the specimens, cured and tested to determine the support coefficient. The results of these tests are shown as Tests 28, 29 and 30 in Table 2 and are plotted on Figure 2. The support coefficient for the mud-wet casing was found to vary linearly with the tensile strength of the cement. The support coefficient was somewhat less than that observed for the plain pipe as shown in Tests 1 through 9.

In the second series of tests on mud-wet casing, the same procedure described previously was used except that after removing from the mud, water was flowed past the pipe to simulate a water wash ahead of the cement. Results of these tests are shown as Tests 31, 32 and 33 in Table 2. The effect of the simulated water wash was to remove essentially all of the mud from the casing such that support coefficients similar to those observed with the plain pipe were obtained. These tests illustrate the advantage of using a water wash ahead of the slurry to increase the casing supporting ability of cement.

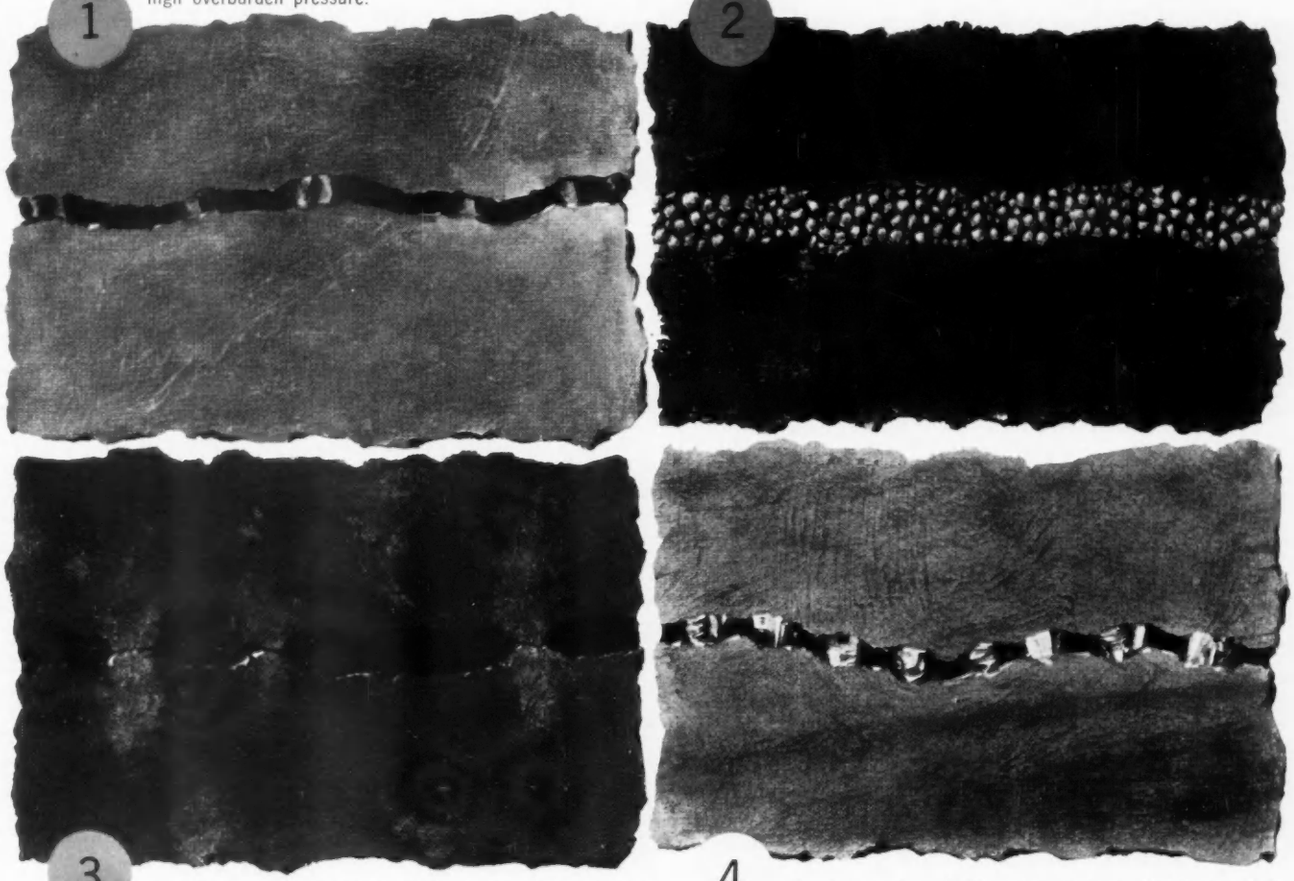
The third series of tests were performed to determine the lower limiting support coefficients for mud-wet casing. In these tests, no attempt was made to remove the mud layer from the pipe prior to pouring cement. Results of these tests are shown as Tests 34, 35 and 36 in Table 2.

Figure 2 shows that the support coefficient for the

TABLE 2—Effect of Type and Strength of Cement On Its Support Coefficient

Test No.	Cement	Tensile Strength psi	Support Coefficient psi
1	API Class A	4	5.35
2	API Class A	18	14.4
3	API Class A	23	26.8
4	API Class A	33	43.8
5	API Class A	53	68.1
6	API Class A	75	102
7	API Class A	83	122
8	API Class A	96	133
9	API Class A	164	251
10	API Class C	7	5.3
11	API Class C	28	29.2
12	API Class C	71	121
13	50:50 Pozzolan-Class A +2% Bentonite	33	25.9
14	50:50 Pozzolan-Class A +2% Bentonite	154	170
15	Class A + 6% Bentonite	8	4.8
16	Class A + 6% Bentonite	27	19.9
17	Class A + 6% Bentonite	81	79.0
18	Class A + 6% Bentonite	101	112
19	Special Cement A	6	3.8
20	Special Cement A	14	15.5
21	Special Cement A	28	35.1
22	Special Cement A	83	127
23	Kerosine Emulsion Cement (48% cement, 22% kerosine, 30% water)	24	23.6
24	Kerosine Emulsion Cement (48% cement, 22% kerosine, 30% water)	77	80.1
25	Kerosine Emulsion Cement (48% cement, 22% kerosine, 30% water)	156	172
26	Class A + 0.7 gal/sack Latex Emulsion	218	333
27	Magnesium Oxychloride Cement	285	349
28	Class A[1]	90	52.1
29	Class A[1]	217	90.0
30	Class A[1]	275	154
31	Class A[2]	64	76.0
32	Class A[2]	217	271
33	Class A[2]	272	350
34	Class A[3]	25	6.4
35	Class A[3]	96	26.0
36	Class A[3]	256	64.8

[1] Mud-wet casing; cement flowed past casing prior to pouring.
[2] Mud-wet casing; water flowed past casing prior to pouring.
[3] Mud-wet casing; mud layer not disturbed prior to pouring.



1 Widely-spaced malleable props, such as rounded walnut shells, propping a fracture in a hard homogeneous formation with high overburden pressure.

2 Sand fully packed into a fracture in a homogeneous formation with low permeability and moderate overburden pressure.

3 No prop is used in an acid-soluble, heterogeneous formation. Retarded Acid etches formation, leaving less soluble portions as prop.

4 Closely-spaced malleable props, such as aluminum pellets, propping a fracture in a medium-hard to soft homogeneous formation with high overburden pressure.

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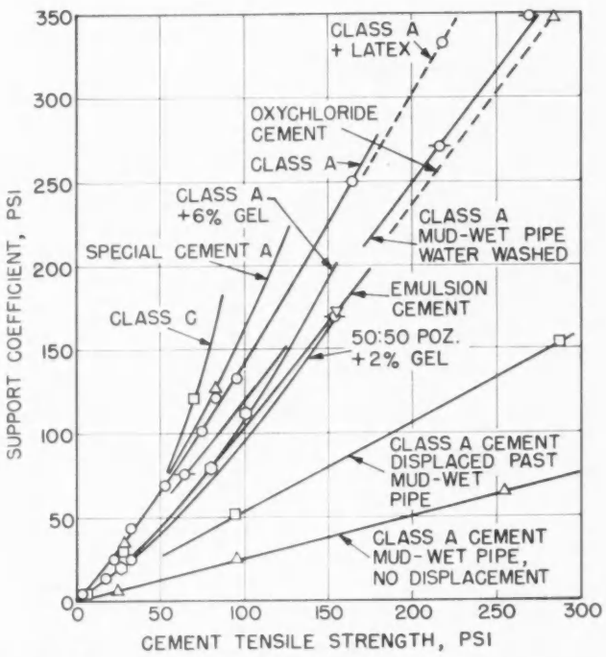

FIGURE 2—Correlation of cement tensile strength and support coefficient.

mud-wet casing (no displacement) varies linearly with the cement tensile strength and may be expressed by the relationship

$$S = \frac{F}{12\,\pi\,d_c\,L} = (0.257)\ ts \qquad (1)$$

Wherein:

S = support coefficient, psi.
F = force to break the cement bond, pounds.
d_c = outside diameter of casing, inches.
L = length of casing, feet.
ts = tensile strength of cement, psi.

As the support coefficient (S) is the force required to cause movement between the casing and cement divided by the outer surface area of the casing in contact with the cement, the preceding relations defines the ability of a cement to support casing as a function of the outside diameter and length of casing, and the tensile strength of the cement.

Other variables, such as the presence of casing collars and lack of a continuous sheath of cement around the casing that affect the ability of the cement to support the weight of casing, are recognized. However, it is thought that the use of equation (1) will provide lower limits on the tensile strength of cement required for field operations.

Effectiveness of low-strength cement in supporting casing. The effectiveness of cement at 8 psi tensile strength in supporting the weight of casing was calculated using equation (1). The results of these calculations in terms of the length of pipe supported by a 10-foot column of cement are shown in Table 3.

The relationship between support coefficient and tensile strength can be used to determine the strength of cement or height of cement column required to support any given casing string by the following equation:

$$ts = \frac{(L)\quad (w)}{9.69\ (d_c)\ (h_c)} \qquad (2)$$

Wherein:

ts = tensile strength of cement, psi.
L = length of casing string, feet.
w = weight of casing, pounds per foot
d_c = outside diameter of casing, inches
h_c = height of cement column, feet

Computations using equation (2) show that if it is desired to cement 9,000 feet of 10¾-inch 45.5 pounds per foot casing with a cement fill of 1,000 feet the cement will require a tensile strength of only 4 psi. Thus, a cement of low tensile strength is adequate to support the weight of casing.

Cements used in oil wells must perform other functions in addition to supporting the weight of the casing—e.g., cements must:

- Withstand the shock of drilling and perforating
- Segregate the different horizons encountered in well

Data indicate that cements of low strength withstand the shock of perforating better than do cements of high strength. It has also been shown that the ability of a cement to withstand the shock of drilling depends upon drilling practices, i.e., if only the drill-collar weight is used in drilling the plug and enough hole to bury the drill collars, cement of only 50 psi compressive strength (5 to 10 psi tensile strength) is adequate.

Finally, the ability of a cement to segregate the various horizons encountered in a well is more dependent upon the quality of the cement job (removal of excess mud and placement of a complete annual ring of cement around the casing) than on the strength of the cement.

These considerations indicate that cements of low strength are adequate for determining WOC time, and, if proper precautions are taken, a tensile strength of 8 psi is sufficient.

STRENGTH OF CEMENTS UNDER SIMULATED CONDITIONS

Testing procedure. Inasmuch as low tensile strengths were proved adequate for supporting the casing and for determining minimum WOC times, the next step was to

TABLE 3—Length of Casing Supported by a Column of 8 PSI Tensile Strength Cement 10 Foot in Length

Casing OD, In.	Casing Weight, lb/foot	Length Supported by 10 feet of Cement
4½	9.5	367
	11.6	301
	13.5	258
	15.1	231
5½	15.5	275
	17.0	251
	20.0	213
	23.0	185
7	20.0	271
	26.0	209
	32.0	170
	38.0	143
8⅝	32.0	209
	36.0	186
	40.0	167
	44.0	152
10¾	40.5	206
	45.5	183
	51.0	163
	55.5	150

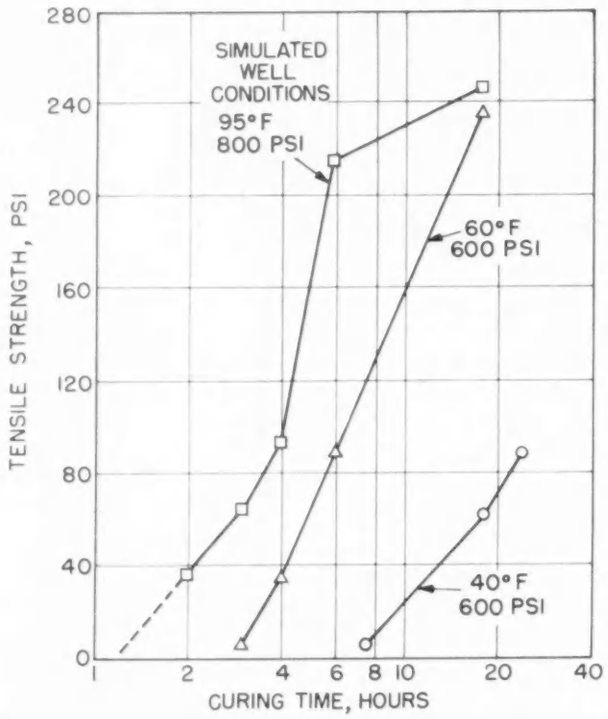

FIGURE 3—Strength development of an API Class A cement + 2 percent $CaCl_2$.

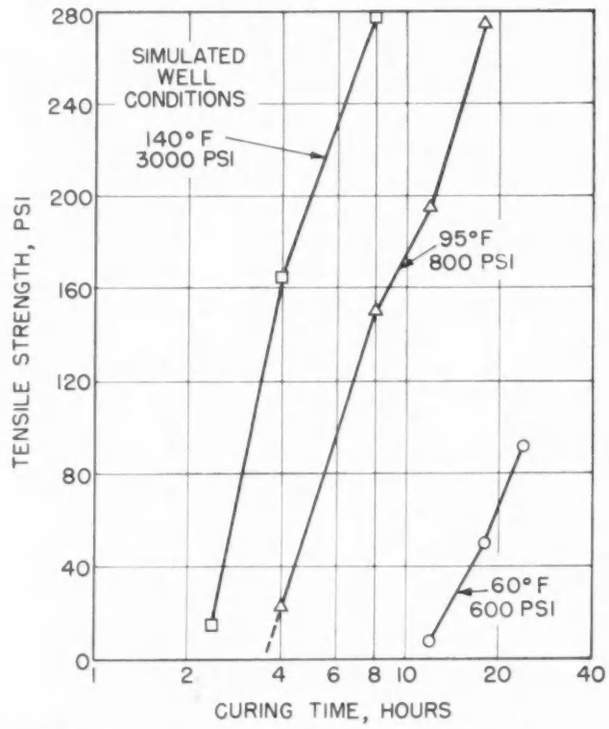

FIGURE 4—Strength development of an API Class A cement.

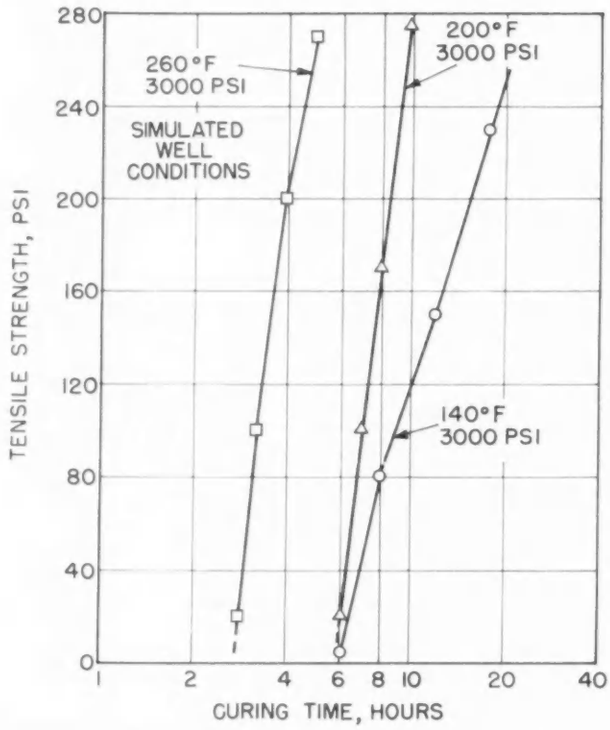

FIGURE 5—Strength development of an API Class D cement.

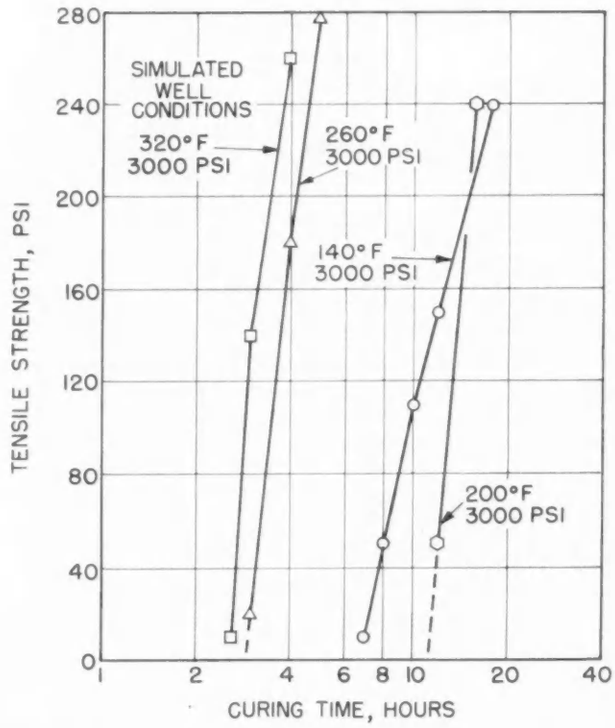

FIGURE 6—Strength development of an API Class E cement.

evaluate the early strength performance of various oil-well cementing compositions under simulated well conditions.

The "Well-simulation Test Schedules for Curing Strength Specimens" given in API RP 10B[1] were used in these evaluations.

In following these schedules, the specimens are placed in water at 80° F and a specified pressure is applied. The temperature is increased over a 4-hour interval to the final test temperature which varies from 95° F to 350° F. In addition to curing specimens according to these schedules, specimens were cured at constant tem-

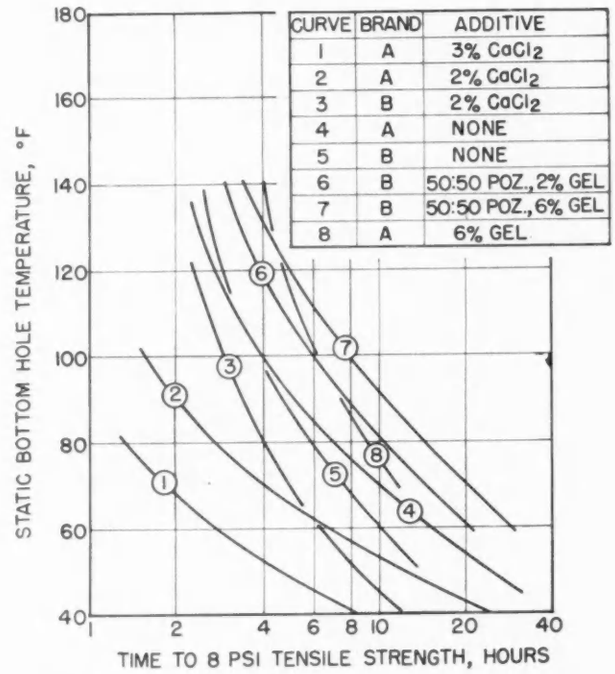

FIGURE 7—Time for cement compositions to develop 8 psi tensile strength (40° F-180° F).

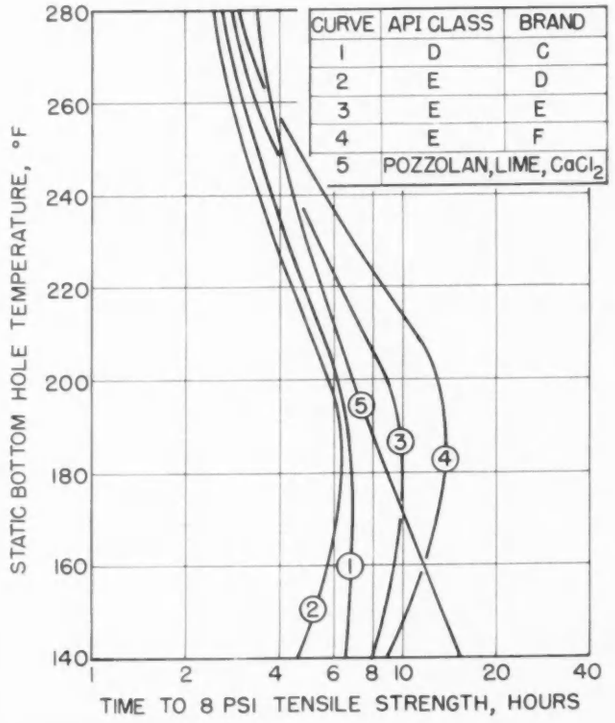

FIGURE 8—Time for cement compositions to develop 8 psi tensile strength (140° F-280° F).

peratures of 60° F and 40° F. A pressure of 600 psi was imposed at these lower temperatures.

Early strength characteristics. Figures 3, 4, 5 and 6 illustrate the early strength characteristics of various oil-well cementing compositions. Figure 3 is the early strength of a typical API Class A + 2 percent calcium chloride at simulated static bottom-hole temperatures of 40° F to 95° F. Figure 4 is a typical Class A cement (neat) at temperatures of 60° F to 140° F. Figure 5 and 6 are typical of Class D and Class E cements, respectively. The significant features of these plots are:

- The rapid increase of strength with time after strength development begins.
- The relatively short time required for strength development to begin, particularly at the higher temperatures.

An interesting phenomenon observed in these tests is that most Class E cements required longer period of time to develop early strength at a simulated static temperature of 200° F than at temperatures of either 140° F or 260° F. The relatively high strengths observed after very short curing periods strongly suggest that considerably shorter WOC times than those currently utilized are feasible.

A PLAN TO ELIMINATE WOC TIMES

Any plan to eliminate WOC times requires that the cement develop adequate strength in less time than that required to perform the necessary rig operations. The preceding laboratory investigation can serve as a basis for such a plan by assuming that a tensile strength of 8 psi is adequate to allow rig operations to be resumed. Cross-plotting of the preceding strength data will show the length of time required for a cement to develop this strength. Shortest WOC times will result from selecting the cement requiring the least time to attain 8 psi tensile strength.

Time required to develop adequate strength. Figure 7 shows the time required to develop 8 psi tensile strength for several brands of Class A cement with and without various additives such as calcium chloride, bentonite and pozzolans.

At static bottom-hole temperatures of 60° F or higher, Class A cements plus calcium chloride will develop this strength in 7 hours or less. Additives such as bentonite and pozzolans generally lengthen the time required to develop 8 psi strength.

Figure 8 shows a similar plot for deep-well cementing compositions. Although the slow-setting cements require somewhat longer time to develop 8 psi strength than the Class A cements shown on Figure 7, ten hours are adequate for most well conditions. By proper selection of cements, 8 psi can be developed in less than 7 hours. Above 240° F, 5 hours will generally be sufficient.

Of particular interest is the tendency for all 3 Class E cements tested to require longer periods to develop adequate strength at temperatures of 180° F to 200° F, than at either 140° F or 220° F. This reversal requires accurate knowledge of both the static bottom-hole temperatures and the performance characteristics of the cement. This strength reversal was not observed on either the Class D cement or the pozzolan-lime blend.

Thickening-time considerations. The strength evaluations have shown that by proper selection of cement, 8 psi tensile strength will be developed in 3 to 7 hours. The

most important factor to be considered in selecting cements for oil-well cementing operations, however, is the thickening time. The cement must obviously remain pumpable a sufficient length of time to allow it to be placed. Therefore, when selecting a cement for short WOC times, limits must be imposed to assure that the cement exhibits adequate thickening time.

To determine minimum thickening time requirements, a recent API survey[2] of field cementing operations was utilized. This survey presented data on 325 casing cementing jobs. The data were re-analyzed by grouping the wells in 2,000-foot depth brackets and plotting cumulative frequency distribution curves of the total cementing times. The time in which 90 percent of the jobs were performed was then plotted against depth and best-fitted with a straight line. A one-hour safety factor was added to this line to arrive at the "minimum thickening-time requirement" line shown on Figure 9.

Once minimum thickening-time requirements are established, the thickening-time depth limit of any particular composition may be determined by plotting the thickening-time—depth relationship and observing the depth at the intersection of the resultant curve with the thickening-time requirement line. Thickening time for 5 of the cementing compositions shown on Figure 7 and 8 are plotted on Figure 9 to illustrate this procedure. Also shown on Figure 9 is the depth-static bottom-hole temperature relationship used in this investigation. This plot shows the depth limitations imposed by thickening-time requirements, as shown in the following tabulation.

Curve No.	Composition	Thickening-time limit: Static Bottom-hole Temperature, Depth, Ft.	Deg. F.
1	Class A, Brand A + 3-percent $CaCl_2$	—	62
2	Class A, Brand A + 2-percent $CaCl_2$	—	87
3	Class A, Brand A (neat)	6,400	176
4	Class D, Brand C	12,000	260
5	Class E, Brand E	14,300	296

With the thickening-time limitations established, an operable plan for selecting comments is to choose the cement composition that requires the least time to develop 8 psi tensile strength and still exhibits adequate thickening-time characteristics.

Typical cementing program. WOC time usually refers to the time interval between initial mixing of the cement at the surface and drilling out or resuming other rig operations. Under the plan presented here, WOC time is divided into two phases.

The first phase covers the time required to place the cement, i.e., to mix, pump and displace the slurry to the bottom. This time is observed directly in the field.

The second phase consists of the time for the cement to develop 8 psi tensile strength as determined from curves similar to those shown in Figures 7 and 8. This time begins after the top cement plug is bumped. Thus, total WOC time equals the time to bump plug plus the time to develop 8 psi strength.

Figure 10 shows a typical cementing program designed to minimize WOC time. The placement time is assumed equal to the maximum total cementing time for 90 percent of all wells; the time to develop strength is the time

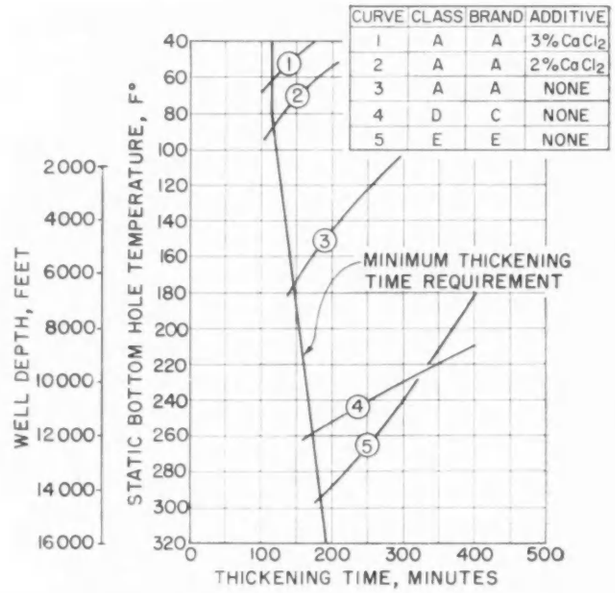
CURVE CLASS BRAND ADDITIVE
1 A A 3% CaCl2
2 A A 2% CaCl2
3 A A NONE
4 D C NONE
5 E E NONE
MINIMUM THICKENING TIME REQUIREMENT
WELL DEPTH, FEET
STATIC BOTTOM HOLE TEMPERATURE, F°
THICKENING TIME, MINUTES

FIGURE 9—Depth limitations of cements imposed by thickening-time requirements.

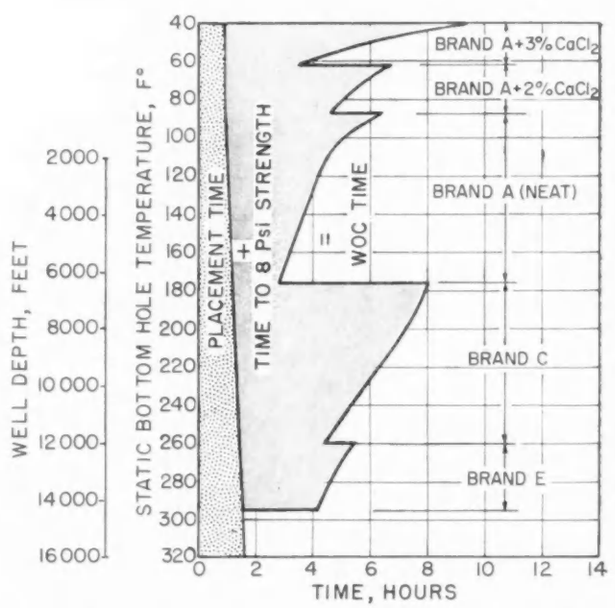

FIGURE 10—Cementing program for minimizing WOC times.

to 8 psi strength as shown on Figure 7 and 8 and the thickening time depth limit is that value determined from Figure 9. The longest WOC time required between static temperatures of 43° F and 280° F is only 8 hours, and at many depths, WOC time less than 4 hours are adequate.

Under most conditions, the design and use of programs such as shown on Figure 10 will eliminate nonproductive rig time and should eliminate the concept of waiting on cement.

FIELD APPLICATION OF REDUCED WOC TIMES

Revised rig operations to utilize short WOC times. Concurrent with the laboratory investigation, a survey of field operations was conducted to determine the prac-

ticability of reducing WOC times from 24 hours to as low as 12 hours. This survey was conducted in Louisiana, Texas, New Mexico, Oklahoma, Kansas, Colorado, Wyoming, Nebraska, Montana and in the Alberta Province of Canada.

The survey showed that rig operations could usually be revised to take advantage of a 12-hour WOC time. In some areas, operations could be commenced after WOC times as low as 6 to 8 hours by utilizing technical know-how to plan the resumption of drilling in a minimum time. Certain practices must be observed.

Use of float equipment. The installation of reliable float equipment eliminates the practice of closing in the casing following cementing operations. This has two distinct advantages. First, well operations, such as nippling up or landing the casing, may be resumed immediately and drill pipe may be run into the hole to resume drilling operations at the minimum WOC time.

A second major advantage of eliminating closing in the casing following cementing operations is in avoiding expanding fluids inside the casing caused by the heat of hydration of the cement. If the casing is shut-in, pressure increases and forces the casing itself to expand over the size it would occupy under normal well-producing conditions. The cement then sets around the expanded casing. When the pressure is relieved, the pipe contracts, leaving a small crack between the casing and the cement.

Tests have shown that this cracking, or parting, is frequently responsible for the inability to segregate one section of a formation from another. The use of a pressure-buildup method to indicate WOC time will destroy the bond between the cement and the casing. In addition, the extreme high pressures developed can cause parting of the pipe, necessitating major remedial operations to effect repair.

The cost of float equipment may be reduced by the use of insert valves that are threaded for installation in the coupling between casing joints.

"Nippling-up" procedure. The field survey of WOC time practices revealed that where pressure was held on the casing, nippling-up procedures did not start for as long as 24 hours. The use of float equipment eliminates the need for holding casing pressure and nippling-up operations can begin immediately after the plug is bumped.

The ultimate plan would be to revise casing operations to eliminate the nippling-up operation required after normal cementing operation. Wellhead equipment would have to be revised to permit installation of a casing bowl on the surface casing at the time it is run so the casing support mechanism will pass through the blowout preventer and seat in the wellhead casing bowl without the necessity of unbolting wellhead equipment following cementing operations.

Pressure testing after cementing. An analysis of pressure testing after cementing indicates that only very limited benefits are derived. The success or failure of the cement job is not positively indicated.

Primarily, the couplings of the casing are tested. If leakage is indicated, it is difficult to determine whether the leak is through the couplings or through the float equipment at the bottom of the casing and out into the formation. On the other hand, considerable damage can result from pressure testing after cementing. Application of high pressure inside the casing subjects the cement around the casing to radial compression. At the low strengths observed after very short WOC times, this stress may cause damage to the cement or to the cement-casing bond.

Other investigators have shown that casing subjected to high internal pressures tends to buckle. This places the casing in tension which may cause the cement to fail in shear. This adds another possibility of destroying the cement under conditions that would not necessarily be imposed on the cement or the casing during normal production operations.

Because of these possibilities, it appears advisable to eliminate the pressure testing of casing prior to resuming operations, or at least, reduce the maximum pressure imposed.

Hazards of short WOC times. The design of a cementing program to minimize down times such as those described involves certain hazards. They are:

- The practice of not shutting-in the casing places full dependency on the float equipment for preventing backflow of the cement. The competency of the float equipment can be verified by checking for backflow after the cement job. If the equipment holds for 30 minutes, it can be assumed satisfactory as most cements will develop a high gel strength in this time which will aid in preventing backflow.
- Selection of a cement on the basis of shortest WOC times. This requires that the cement be selected in accordance with its strength-development characteristics at the static bottom-hole temperature to which it will be exposed. In the past, a safety factor on thickening time has been afforded by over-estimating bottom-hole temperature. Selecting cements for minimum WOC times prevents this practice. Therefore, relatively accurate estimates of bottom-hole temperatures must be made. Selection of a cement on the basis of shortest WOC time also necessitates careful laboratory simulations of field conditions.

The design of cementing programs to utilize WOC times based on cement of 8 psi tensile strength is intended not only to eliminate non-productive rig time, but to provide maximum protection at the earliest possible time. It should be pointed out, however, that the acceptance of low early strengths as adequate for supporting the casing does not imply acceptance of low ultimate strength cements. Available data indicate that both low early strength and high ultimate strength can be obtained by properly selecting the cement composition for the well under consideration.

This article is based on a paper entitled "Engineered Cementing Operations to Eliminate WOC Time," presented at the API Spring Meeting of the Mid-Continent District, Division of Production, Tulsa, April 5-7, 1961.

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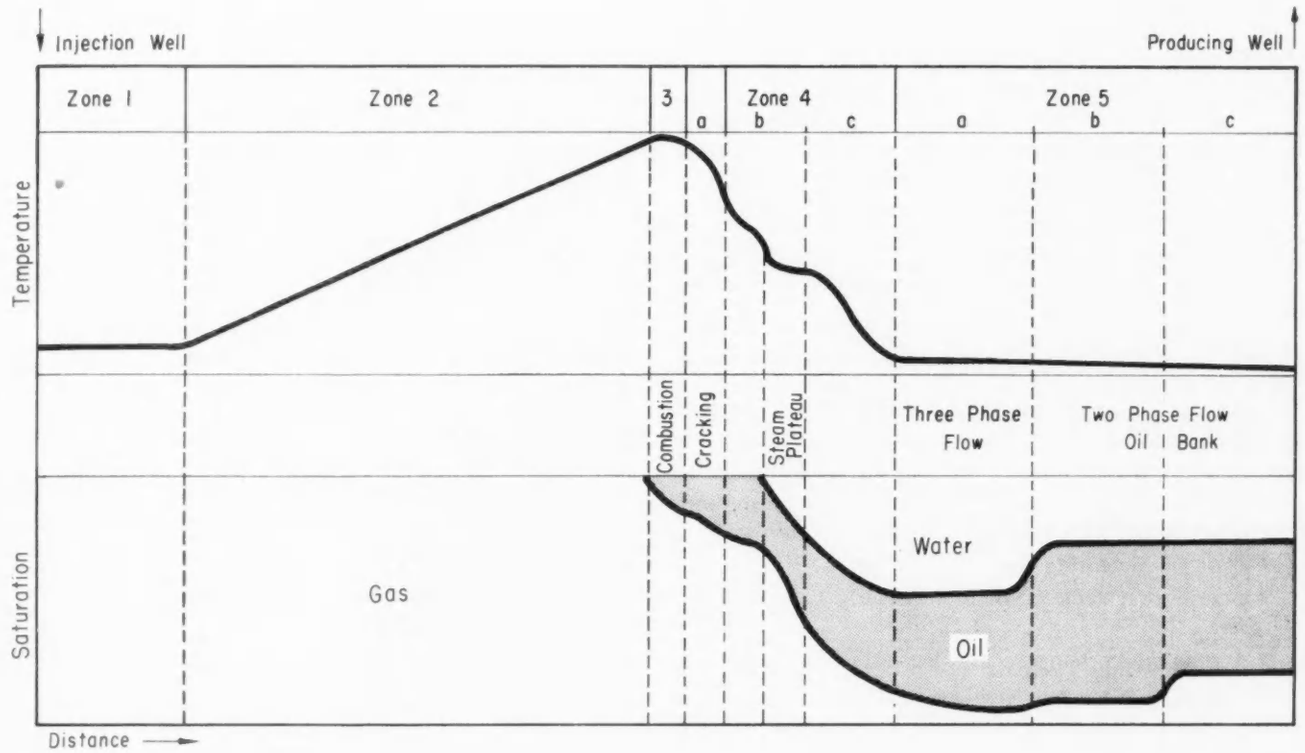

FIGURE 1—Here are temperature and saturation profiles of a heat wave. Successive temperature zones may be described as: (1) low temperature zone around the injection well; (2) zone of increasing temperature; (3) combustion zone of high and fairly constant temperature; (4) zone where temperature decreases in the direction of flow, and (5) low temperature zone ahead of the moving wave.

Evaluating the heat wave process

Economic success of in situ combustion projects is dependent on compression costs and oil content per unit bulk formation volume

By Dr. Stephen E. Szasz, Research Associate
Sinclair Research Laboratories, Inc., Tulsa

THE ORIGINAL INCENTIVE for development of the heat wave process was the tremendous volume of oil left in the average formation after primary and secondary depletion; that is, the need for a tertiary recovery process. Thus the heat wave process appears in a new light. Its main characteristic is that the injection requirement, and the cost of the process, is proportional to the bulk volume of the swept portion of the reservoir and not to the oil content or pore volume. The following are important considerations.

• The profitability of the process depends mainly on compression costs and oil content per unit bulk formation volume since the ratio between injected gas (air) and formation volume swept is high. This is why most field

tests to date have been conducted in high-porosity reservoirs containing heavy crude, which easily retain (after depletion by conventional means) an oil content on the order of 1,000 barrels per acre foot.

• The best time to start a heat wave project is as early as possible in the life of a field; that is, as soon as adequate effective permeability to gas can be established. Then, the process will remove all oil from the swept formation at a cost which depends only on the bulk volume of the reservoir. Any time elapsed and any steps taken after the earliest moment are wasted, because the same oil would be recovered anyway at no additional cost during the heat wave process.

Qualitative Picture of a Heat Wave

In the simplest thermal recovery process, air is introduced into injection wells. After ignition, some of the oil in place burns and generates heat in the formation, in place (in situ). The combustion front as well as liquid and vaporized oil move with the injected gas toward the producing wells. Five successive temperature zones shown in Figure 1 exist:

- Low temperature zone around the injection well
- Zone of increasing temperature
- Combustion zone of high and fairly constant temperature
- A zone where temperature decreases in the direction of flow
- Low temperature zone ahead of the moving heat wave.

The flowing fluid, or fluids, remove heat from Zone 2 and carry it into Zone 4, thus moving the heat wave forward. Also, conduction causes forward heat flow in Zone 4 and backward in Zone 2. New heat is generated in Zone 3.

Considering material transport, it is assumed that at the start, the formation contains immobile water, but mobile oil and gas saturations. At a given point in Zone 5, oil flow is at first due to the original oil content being displaced by the flowing gas (Zone 5c). Later, flow is assisted by an oil bank which is formed by water moving ahead of the heat wave (Zone 5b). Finally, close to the advancing heat front, the water saturation is built up to the point where gas, oil and water are flowing (Zone 5a).

When the forward edge of Zone 4 passes and the temperature starts rising, some light components of the oil vaporize and are carried in the gas stream. However, because they move faster than the heat wave, they soon hit colder areas where they recondense.

The same thing happens to water. In Zone 4c, the original oil is subjected not only to gas and steam drive, hot water drive and vaporization, but also to miscible displacement by the vaporized and recondensed light components. Zone 4b contains no liquid water because of sufficiently high temperature, and oil moves only by distillation-recondensation and gas drive.

When the cracking temperature (about 700°) is exceeded (Zone 4a), part of the oil is chemically changed into two products—a volatile fraction and a non-volatile residue. Some of the volatile fraction recondenses further downstream, but some is light enough to remain in the produced gas to which it imparts a certain heating value. The non-volatile residue consists of coke, tar and/or pitch which constitutes the primary fuel for combustion. In addition, reaction kinetics may be such that some oxygen also reaches movable oil which burns. The resulting saturation profiles are shown in Figure 1.

Zone 4 also is characterized by interaction between material and heat transport. Oil and water in both the liquid and vapor phase, contribute to the heat carrying capacity of the flowing fluids. Chemical and phase changes in the solid matrix and vaporization-condensation have thermal effects. As a result the temperature profile has a smooth, gentle slope in Zone 2, but a sharper, irregular slope in Zone 4.

Quantitative aspects of the temperature profile are influenced by vertical heat flow (by conduction) toward the originally cold over- and underburden. This causes heat loss from the system. No present theory can completely describe such a complex system.

Quantitative Description of Heat Wave Process

Quantitative aspects of the basic heat wave process will be discussed according to: gas requirement, rate of injection and production, liquid oil recovery efficiency and volumetric sweep efficiency.

Gas requirement. The gas requirement is defined as the volume of oxygen-containing gas (in the basic case, air) in standard cubic feet required to carry the heat wave forward over one cubic foot of formation. Laboratory experiments reported in the literature[1,2,3,4] give values between 230 and 1300 cu.ft./cu.ft. Field tests[2,5,6] indicate a range of 350-700 cu.ft./cu.ft. No satisfactory method is available to account for, or to predict this figure.

If heat conduction is neglected, considerations of heat exchange indicate a gas requirement of about 1620 cu.-ft./cu.ft. with air, or 1250 cu.ft./cu.ft. if the heat carrying capacity of oil and water in a typical formation is included. Thus, it is evident that 50-75 percent of the heat moves ahead of the wave by conduction. In one field test,[5] this required a width of 17 feet for Zone 4. This was substantiated by two window wells at a radial distance of 30 feet from each other, one being cool and unaffected by the heat wave, the other already burned out.

Basically, the goal of a theory of movement of the heat wave is to give the temperature as a function of time and distance (radial or linear, depending on the system). It would also include peak temperature and

indicate the maximum distance (or for how long) the wave could be kept "alive" i.e. exceeding some minimum ignition temperature.

This function is a solution of a differential equation (with suitable boundary conditions) which includes terms for heat exchange between stationary matrix and flowing fluids, heat conduction forward and backward, heat generation in the proper amount and in the proper place and for other endothermic or exothermic effects. No complete approach such as the above has been published.

Attempts to determine the movement of the heat wave have proceeded along three different lines of thought:

1. Classical concepts of fluid flow and material balance have been used to calculate the movement of the three phases.[4] In addition, the amount of oil burned, etc. is calculated from the heat capacity of the rock and from peak temperature which have assumed to be known. No consideration is given to the mechanism by which heat moves forward.

2. Some investigators[7,8,9] have taken into account heat exchange and heat conduction, but assume that heat is generated only in a narrow zone, the movement of which is known. This means that the amount of fuel burned per unit reservoir volume is known. They predict correctly that the width of Zone 4 increases with time; thus, the point in Zone 4 representing the average front of oil removal travels faster than the burnoff point at the rear edge of Zone 3. These calculations also show that a steady-state temperature profile does not develop.

3. The preceding methods depend on knowledge of peak temperature or amount of fuel. These data are presumably obtained from laboratory experiments. Several attempts[3,4] have been made to determine these values as well as the behaviour of a heat wave from laboratory experiments in systems artificially heat-compensated to make them quasi-adiabatic and thus eliminate excessive heat losses which would distort results. However, these systems were not entirely adiabatic. They were of linear rather than radial geometry, and gas flux rates were higher than those in the field.

To yield acceptable results, laboratory experiments would have to duplicate field conditions as well as the history of the system. This would be necessary to account for the influence of miscible displacement by distilled and recondensed components ahead of the heat front. Also, in the absence of complete theoretical understanding, the scaling procedure to translate laboratory results into the field is not reliably known.

Rate of injection and production. Field tests conducted so far have been operated at air injection rates between 500 and 5,000 scfh/ft. of sand thickness. The minimum flux reported for laboratory work in a linear system was about 10 scfh/ft.[2] which corresponds to the flux at 8-80 feet from an actual well bore.

The fluid flow rate is determined by:

- Injection pressure, which depends primarily on depth (about 1 psi/ft. of depth).
- Producing well pressure, which is governed by practical considerations (pumping or flowing wells).
- Well spacing, which is determined by economic considerations (deep wells are more expensive to drill, equip).
- Resistance to flow of the various fluids. This can be treated on the classical grounds of relative permeability for Zones 1, 2 and 5. The continuously changing viscosity and saturation in Zone 4, and the exchange of material between phases, make this zone practically impossible to calculate. Fortunately, its overall influence is small because during most of the life of a project, it makes up only a small portion of the total flow path. The total flow resistance is determined primarily by the three-phase-flow Zone 5a.

Two practical conclusions may be derived from the preceding discussion. First, the viscosity of the oil at original formation temperature (which enters into calculation of the flowing GOR in Zone 5a) is an important factor in determining the technical and economic performance of the process. Second, the producing gas-oil ratio depends on whether the producing well is in Zone 5c or already in 5b or 5a. In the initial stages an ordinary gas drive also is superimposed upon the heat wave process proper. Thus, the economics of a particular project can be improved if the project can be stopped before the producing GOR reaches excessive values.

It should be noted that oxygenated compounds of a polar nature in the produced oil may cause emulsion trouble. Also, fresh water condensing ahead of the wave may cause clay swelling in water-sensitive formations.

Liquid oil recovery efficiency. Liquid oil recovery efficiency is defined as the ratio between oil recovered from the volume of formation subjected to the heat wave and the initial oil content of the same formation volume at the time the process was started. No reliable recovery efficiency data are available from field tests. Only two such tests have been carried to anything approaching completion. One[12] was characterized by combustion above ground and the other[6] by a combination of heat wave, gravity drainage and gas drive.

Early estimates which ranged from 85 percent to as high as 98 percent were based on losses by combustion only, and appear to be optimistic. Only at a later date were the following factors realized:

1. Laboratory experiments to determine loss of oil as fuel were conducted in unconsolidated sand packs where the residual oil content after gas drive is low. The advancing heat wave "sees" only this saturation and derives from it (by distillation and coking) a residual fuel content which is too low in comparison with field conditions.

2. Experiments conducted at low pressure and at a fast flow rate favor removal of oil by distillation, thus leaving too little material for subsequent coking.

3. Recent insight into chemical kinetics has shown that some removable oil will burn because it has a lower ignition temperature or, at the same temperature, a higher reaction rate than coke. There are indications that under some conditions, the true immobile residual may

constitute only half of the total fuel consumption. Work indicating a surprisingly high atomic H:C ratio of 1.6 for the residual fuel points in the same direction.[13]

4. Cracking at high temperatures generates not only coke, but also volatile components which wind up ultimately in the produced gas and impart to it a heating value of perhaps 50 Btu/cu.ft.—not enough to make it valuable. Some of this may be due to the stripping action of the gas stream, but unsaturates including CO and even some hydrogen, in the produced gas must have been generated by cracking. These components must be deducted from the original oil when calculating a material balance.

A material balance of this type follows:

- Original oil content, 1,000 bbl./a.ft.
- Gas (air) requirement, 15 MMcf/a.ft.; heat generated 1.5 x 10^9 Btu/a.ft., equivalent to 250 bbl./a.ft. oil burned.
- Heating value of produced gas, 50 Btu/cu.ft., total 0.75 x 10^9 Btu/a.ft., equivalent to 125 bbl./a.ft. oil.
- Liquid oil recovery, 1,000 — 250 — 125 = 625 bbl./a.ft., or 62.5 percent.

Little work has been done on the composition of the produced gas, although it may furnish reliable indications whether the heat wave is progressing normally. For example, an increase in the residual oxygen content means trouble if it indicates a decrease in combustion efficiency due to a decline in peak temperature.

Volumetric sweep efficiency. Volumetric sweep efficiency is defined as that fraction of a given reservoir which will ultimately reach a temperature high enough for substantially complete oil removal. This factor is always less than unity for two reasons: incomplete areal coverage from any given array of wells (areal sweep efficiency), and incomplete thickness coverage (vertical conformance factor).

No field experimental values of areal sweep efficiency are available because all tests reported were either incomplete or conducted under unconfined conditions. In at least one, the swept area extended beyond the confines of the well pattern.[6] However, an areal sweep slightly better than for conventional gas drive is to be expected because of lateral heat conduction. This problem has been studied on a potentiometric analog model.[14]

Values between 30 percent[6] and 100 percent[5] have been calculated for the vertical conformance factor in field tests. Initially, it was thought that the vertical conformance factor would be 100 percent since heat can spread vertically by conduction even into tight streaks. However, most field tests did not achieve this goal, apparently because of a heating period of insufficient length and because of excessive gravity drainage. It now is realized that another factor might also have had an influence. Because of heat losses, the producing formation near the overburden may not reach ignition temperature. At least some, if not all, of the residual oxygen in the produced gas is due to unreacted air flowing through these strata.

Variations of the Basic Process

Attempts to improve the performance of the basic process have led to the following suggested variations:

Injection of hot gas and steam. In one project, a hot mixture of flue gas and steam was generated in a combustion chamber and injected into the center well of an unconfined five-spot, presumably to utilize the heat carrying capacity of the steam.[12] Gas requirement (excluding steam) was high (550 cu.ft./cu.ft.), probably because of low oxygen content of the injected mix. The gross oil recovery was estimated at 80 percent, but since the affected area was unknown, this figure is doubtful. Even so, in an economic appraisal the fuel requirement of the combustion chamber must be deducted, leaving a net recovery of about 50 percent.

Control of injected oxygen concentration. A mixture of air and produced gas was injected for a certain period in another field test.[5] Results for this period could not be segregated, but the overall gas requirement of 345 cu.ft./cu.ft. was the lowest reported to date, despite the fact that oxygen consumption was only 13 percent of the injected gas.

The purpose was to establish an optimum ratio between heat generating capacity and heat carrying capacity of the injected gas. It is believed that too much oxygen may result in an unnecessarily high peak temperature and high heat loss. In addition, the combustion zone may be extended so far forward that some vaporized, otherwise recoverable oil is burned in addition to residual fuel.

Optimum oxygen concentration depends mainly on the nature and amount of oil in the reservoir. Below 30 gravity, straight air injection is best. Economic reasons generally prohibit use of pure oxygen. If indicated, oxygen dilution is most economically performed with produced gas available under pressure.

Injection of gaseous fuel. In reservoirs containing light oil and too little residual fuel, injection of some recycle gas along with air can supplement the fuel at little extra cost. The peak temperature must be maintained high enough to burn both residual and gaseous fuel. No field test of this variation has been reported.

Alternate injection of air and gas. Heavy crudes which respond poorly to more conventional methods and often occur in reservoirs with high oil saturation may deposit too much residual fuel. Alternate injection of air and recycle gas has been suggested, the latter to carry the heat front forward so that upon subsequent air injection, some residue is left unburned because its temperature is too low for ignition.[1] This is equivalent to a reduction in average residual fuel content. No field test information concerning this method has been published.

Incomplete thickness coverage. During one field test in a heavy crude reservoir,[6] it was determined that if the combustion front proceeds only through part of the reservoir thickness, adjacent portions are heated by conduction and produce substantial amounts of oil by gravity drainage and straight gas drive because of reduced viscosity. This can be done intentionally. Despite worsening of the

vertical conformance factor, the process may be economically superior. The main drawback is that the producing wells must be operated even after heat front breakthrough.

Reverse burning. If a reservoir contains extremely viscous crude (Athabasca tar sand), its mobility may be so low that no significant flow is possible. Worse, the oil may bank up and completely block any permeability to gas. In such a case, it has been suggested[15] that the heat wave be made to move in reverse. That is, the producing well would be ignited and heat would move in a direction opposite to that of gas flow. Thus, oil once set in motion would pass only through areas of high temperature where its viscosity would be low and where, by cracking and visbreaking, it might even be permanently upgraded. No field test of this process has been officially reported as yet.

If conditions similar to those in the basic case are considered, reverse burning is possible only if heat transport by conduction countercurrent to the air flow exceeds forward transport by the moving gas. This is possible.

It has been pointed out that field tests with "forward" burning have indicated that as much as 75 percent of the total heat movement may be by conduction. However, this movement must be expected to be slow, because only the difference between the effect of conduction and convection is available to move the heat front as opposed to the sum of the two effects in forward burning. Thus, a high gas requirement would be expected, as well as a low liquid recovery efficiency, because the fuel is movable liquid or vaporized oil, and not residue left behind.

Theoretical and experimental analyses of the process as applied to Athabasca-type formations have been published.[16,17] These studies show the rate of propagation of the reverse burning front can be quite high and the peak temperature surprisingly low, because the combustion zone is not narrow. In fact, since there is some finite, although small, reaction rate between crude and oxygen even at normal temperature, the reaction zone extends all the way to the injection well. However, the optimism of this evaluation must be tempered by the realization that if heat is continuously generated in the vicinity of the injection well, this area is likely to slowly heat up to the point of auto-ignition.

About the Author

Dr. Stephen E. Szasz was graduated from the University of Bucharest, Rumania, with a Ph.D. in physical chemistry. After graduation he joined the Research Department of Astra Romana, a subsidiary of the Shell Group, and worked on problems involving natural gasoline, PVT analysis, reservoir engineering, development of BHP tools and oriented coring. Just prior to the Russian occupation, he escaped to Southern Germany and was employed by the French Military Government. He came to the United States in 1952 and joined the Production Research Department of Sinclair Research Laboratories, Inc., where he is presently a research associate.

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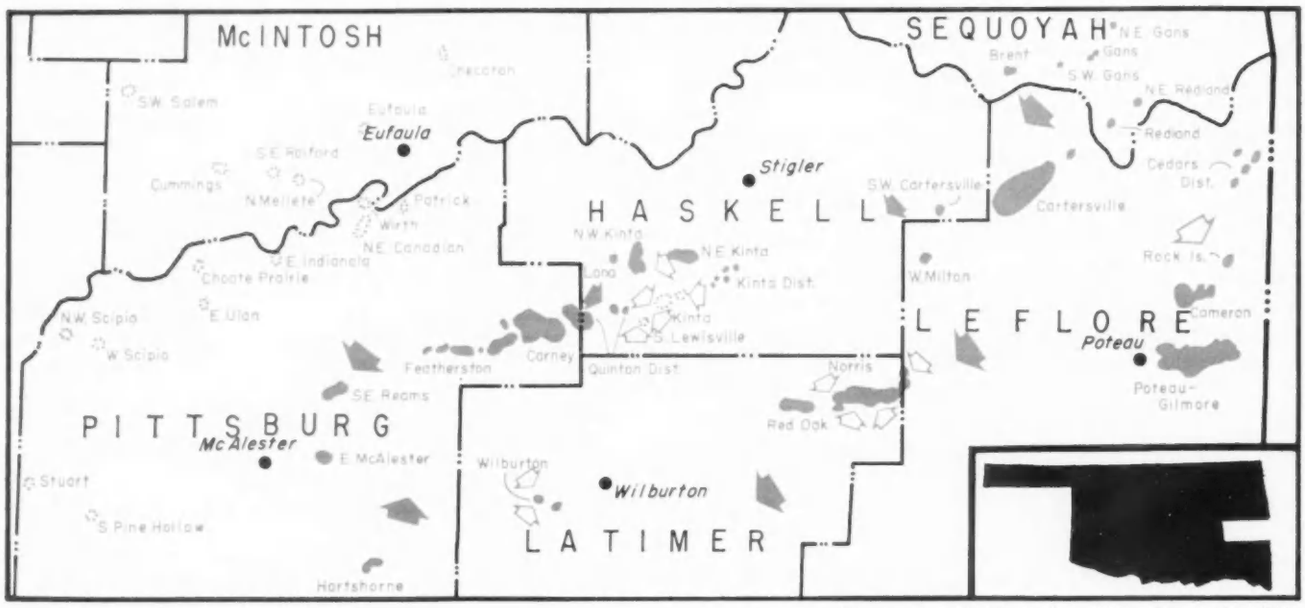


Map courtesy E. C. Jacobson Maps, Inc., Tulsa, Okla.

Oklahoma drilling activity in the Arkoma Basin is shown on the above official pool nomenclature map where 23 rotary drilling rigs are engaged in one of the nation's most active gas plays. Wildcat drilling rigs are shown by large solid arrows. Field wells, principally at Wilburton, Red Oak (Norris) and Kinta fields are portrayed by small hollow arrows.

Deeper gas pays spur Arkoma Basin activity

Major oil companies and independents have 46 rigs operating in this promising 13 county Oklahoma-Arkansas area

By Joseph A. Kornfeld, President
Kornfeld International, Tulsa, Oklahoma

SPRAWLING OVER 13 COUNTIES, the Arkoma Basin of southeastern Oklahoma and western Arkansas is the locale of one of the most active gas plays in the nation.

Adding to the interest is assurance by major operating companies that a big-inch natural gas line will be laid in the basin during the coming year. To this end, a large number of operators have purchased substantial working interests along the most pronounced anticlines (containing the largest semi-developed gas reserves) in the basin.

To assure this major reserve, large companies are participating with strong independents who pioneered the play to the point where more than 7 million acres now are under lease. About 3 million acres are in southeastern Oklahoma, and 4 million in western Arkansas.

Major drilling operations. A survey of current drilling activity reveals that 46 rotary drilling rigs were active on July 11 throughout the Arkoma Basin.

Exploratory drilling is about evenly divided between the two states, with eight wildcats listed for Oklahoma and seven for Arkansas. There are 31 development wells now drilling in semi-proven discoveries, most of which were found in 1960. Fifteen of the wells are in four Oklahoma counties, 16 are in five Arkansas counties.

Independents active. Both major companies and independents are well represented in the two-state Arkoma Basin play.

Included among the leading independents are: Ambassador Oil Corporation, Fort Worth; Bond Oil Corporation, Dallas; Midwest Oil Corporation, Fort Worth; Republic Natural Gas Company, Dallas; Apache Oil Corporation, Tulsa; LeFlore County Gas and Electric Company, Poteau, Oklahoma; J. M. Huber Corporation,

Air Drilling in the Arkoma Basin

Editor's note: Falcon Seaboard Drilling Company, Tulsa, currently operates five drilling rigs in the Oklahoma and Arkansas portions of the Arkoma Basin. These medium to deep depth range rotaries are set up on contract requirements ranging from 7,000 to 14,000 feet, using 4½-inch drill pipe.

In this exclusive World Oil interview, Falcon Seaboard Drilling Engineer Ed Arnold explains air drilling performance vs. drilling with mud in the Wilburton (Pennsylvanian) gas field, one of the newest fields in the hottest deep gas play in the Mid-Continent area.

Q *Mr. Arnold, when did Falcon Seaboard start its first air job in the Arkoma Basin?*

A In the fall of 1960, when it spudded the discovery well for the Wilburton gas field, Latimer County, at Ambassador Oil Corporation et al's Williams Unit 1.

Q *What are the advantages in drilling with air?*

A Time, in some instances. None of our contract wells have been drilled entirely with air, or with mud. While using air, penetration rates are approximately three to four times that experienced with conventional mud drilling.

Q *What is the longest section you have drilled with air?*

A Williams Unit 1, the discovery well of the Wilburton gas field, required only 35 days while air drilling from 389 to 8,811 feet. Maximum bore hole deviation was 2 percent.

Q *Did you experience any improvement in drilling with air, compared with mud, at the west offset of Ambassador Oil Corporation et al's R. F. McAlester 1?*

A No. About the same rate of penetration was experienced. Approximately 24 days elapsed in air drilling from 1,580 feet to 7,260 feet, with maximum deviation of 3 percent at 4,000 feet—and an average deviation of 2 percent.

Q *How much weight do you carry on an 8⅝ inch bit during air drilling operations, compared with weight carried during conventional mud drilling?*

A In the McAlester Unit 1 well, weight on bit did not exceed 5,000 pounds, compared with a maximum weight of 40,000 pounds when conventional mud was used.

Q *What economic advantages result from air drilling?*

A Actually, the contractor does not realize a great amount of economic advantage from the time saved, since all of our drilling contracts made in the Wilburton field were entirely on day work. Ultimately, however, the savings are realized by the operating company.

In this field, drilling conditions still are more or less indeterminate. It is difficult to determine from one well to another where you have to mud up. Moreover, the character and direction of major field faults are not yet known; neither is there sufficient geological control obtained to date from the few wells drilled to permit optimum correlation between wells.

Borger, Texas; Kingwood Oil Company, Okmulgee, Oklahoma, and Samedan Oil Corporation, Ardmore, Okla.

More than 20 major oil companies are operating in the area.

Geology. The area of interest in the Arkoma Basin covers more than 9,000 square miles. An additional 5,000 square miles lies in the front belt of the Ouachita Mountains, known as the Ouachita facies. An additional 7,000 square miles lies in the Boston Mountains. Sediments range in depth from 2,000 to 40,000 feet beneath the surface.

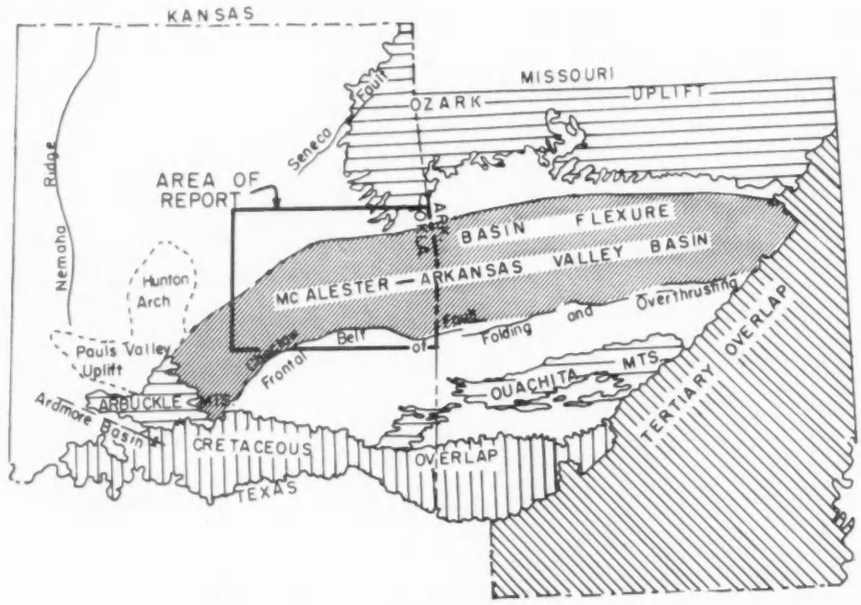
Gross sediment volume for all three provinces, according to the Tulsa Geological Society, is about 55,000 cubic miles, assuming an average thickness of about 2.6 miles. Of this total, about 50,000 cubic miles lie at depths of less than 20,000 feet.

North of the Choctaw fault, in the northern and northwestern portions of the region described above, the pre-Mississippian beds comprise a more or less complete section of Paleozoic rocks ranging in age from upper Cambrian through Mississippian, featured by numerous unconformities and local overlaps. The facies of deposition, variously described as the Ozark or Arbuckle type, occupies a platform position, and includes marine shales with some limestones, and Wilcox-type sands in the Ordovician.

South of the Choctaw fault, the pre-Pennsylvanian facies is featured by the Ouachita type, with predominately siliceous shales, novaculites, cherts, and thick sandstone bodies. The Ouachita area is the locale of a deep geosyncline.

DEEPER DRILLING PAYS OFF

Deeper drilling in the Oklahoma portion of the Arkoma Basin has yielded major natural gas reserves during the past several months at Kinta, Red Oak (Nor-



Courtesy Dallas Geological Society and Ardmore Geological Society

Tectonic map of Arkoma basin (McAlester-Arkansas Valley Basin) showing area covered by this report and principal geological features of the surrounding region.

ris), Wilburton, Quinton, Rock Island, and Cartersville —all shallow gas fields.

Kinta. Lying in southwestern Haskell County, the field was discovered in 1931, with sandstone production from 750 to 1,350 feet in the Hartshorne series of lower Pennsylvanian Age. During 1937, Spiro sandstone production was found at 5,608 feet.

In recent months, Ambassador Oil Corporation Davenport 1 extended basal Atoka sandstone production at 5,542-70 feet.

Kinta Northwest field was discovered March 18, 1960 by Apache Oil Corporation Alva H. Williams 1, for an initial open flow of 8 MMcf per day after fracture treatment through a series of perforations from 5,682-84, 5,687-96, and 5,699-5,702 feet in basal Atoka topped at 5,678 feet.

Red Oak (Norris). The Red Oak area in Latimer and LeFlore counties was discovered in 1912. Subsequent development from 1,500 to 2,100 feet in the Hartshorne sandstones has produced nearly 50 billion cubic feet of gas.

Deeper drilling during 1960 uncovered two deeper Pennsylvanian high pressure gas reservoirs at 7,250 feet in the Atoka sandstone, and at 11,540 feet in the Spiro sandstone. Currently, seven deep drilling operations are underway in development of these two deeper reservoirs.

The Red Oak (Norris) gas field is on the Brazil anticline which extends for nearly 20 miles in a generally west-east strike.

Wilburton. Located on the Heavener anticline, the Wilburton shallow gas field was discovered in 1925, producing from Atoka sandstones at about 2,700 feet.

Deeper production was found December 15, 1960 in the Spiro sandstone by Ambassador Oil Corporation et al's W. M. Williams Unit 1, which was completed for an open flow potential of 8.3 MMcf per day natural flow through casing perforations from 8,811-8,831 feet after drilling to total depth of 9,704 feet.

Deeper Cromwell sandstone production was discovered at the west confirmation well of the same operators' R. F. McAlester Unit 1, which was finaled for 7.6 MMcf per day open flow calculations after acid treatment of perforations from 9,216-9,247 feet. The well was dually completed in the basal Atoka sandstone at 8,288-8,328 feet, which drew on open flow potential of 9 MMcf per day.

Quinton. The Quinton area, which comprises the Carney, Featherston and Quinton fields, lies in eastern Pittsburg County and southwestern Haskell County.

Drilled on the Kinta anticline, the Quinton field was discovered in September 1915, by Nottage Fee 1, one-fourth mile south of the town of Kinta. Its completion resulted in development of 130 gas wells along the crest of the Kinta anticline extending in a southwesterly direction into southwestern Haskell County—including the Featherston-Blocker and Carney fields. More than 150 billion cubic feet of gas have been produced from these wells to date.

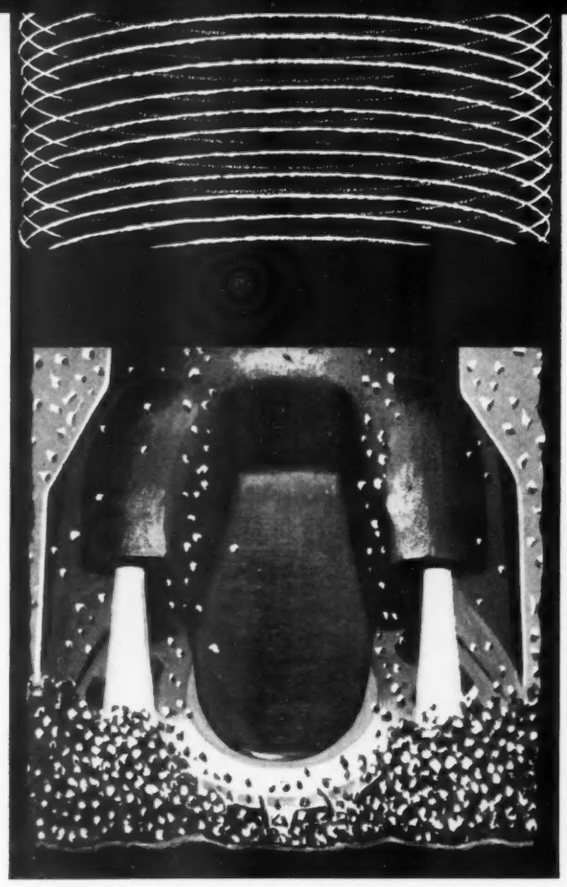
In Haskell County, Mobil Oil County Quinton 1 found Spiro sandstone production at 5,862-5,920 feet, and Cromwell sandstone production at 6,305-6,333 feet in a dual completion. An extension was made from basal Atoka gas reservoir by Ambassador Oil Corporation et al's Steele 1 on April 11, 1960 through perforations from 5,656-66 and from 5,668-78 feet.

At this writing, five development wells are underway in the deeper drilling programs along the Kinta anticline.

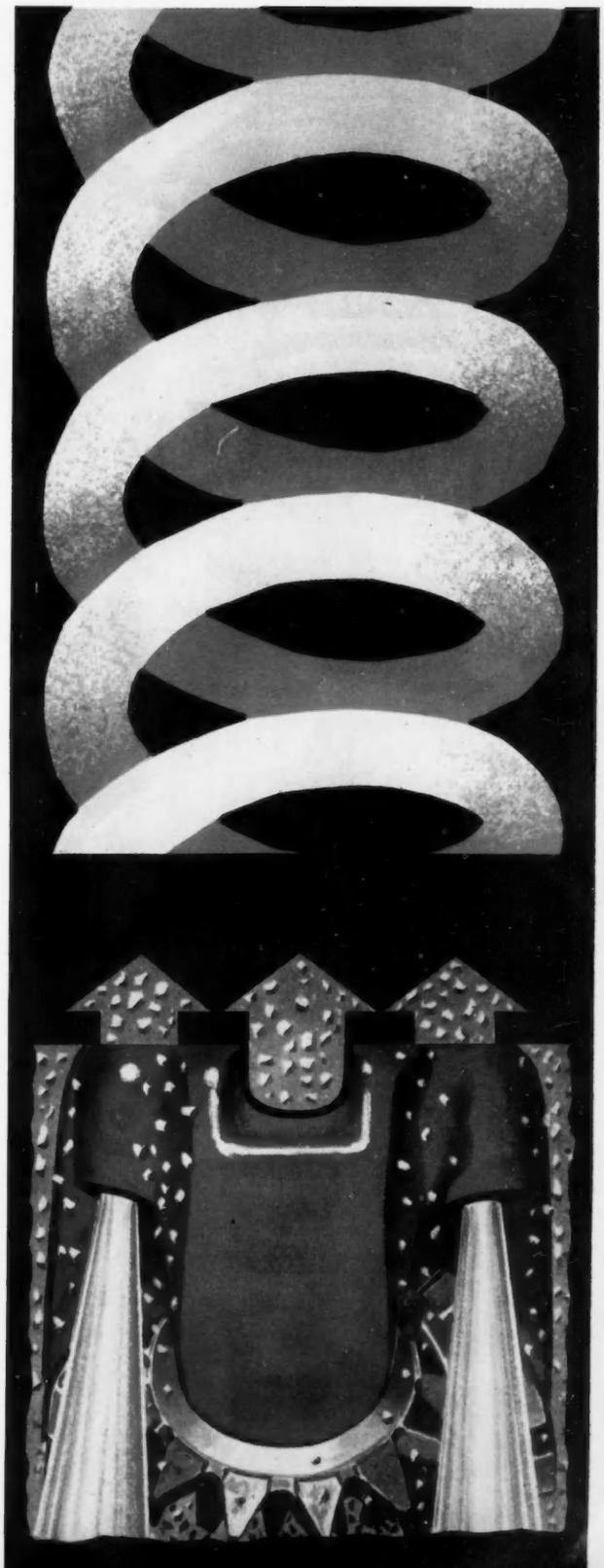
Rock Island. Lying on the backbone anticline in extreme northeastern LeFlore County, the Rock Island field was discovered in 1922, producing from sandstones in the Hartshorne series at depths from 1,365 to 1,990 feet.

Deeper gas production was found in the basal Atoka formation by Midwest Oil's Morris 1, which flowed 1.8 MMcf per day from 5,202-62 feet. A confirmation well is being drilled.

Cartersville. Earliest development in the Cartersville-Spiro fields on the Milton anticline in northern LeFlore County took place in 1930. Fifteen shallow gas wells were completed from the Atoka series at an average pay depth of 1,480 feet. From this development, nearly 100 billion cubic feet of gas were produced during the following 30 years by the Fort Smith Gas Corporation. —**The End**



milling or drilling?



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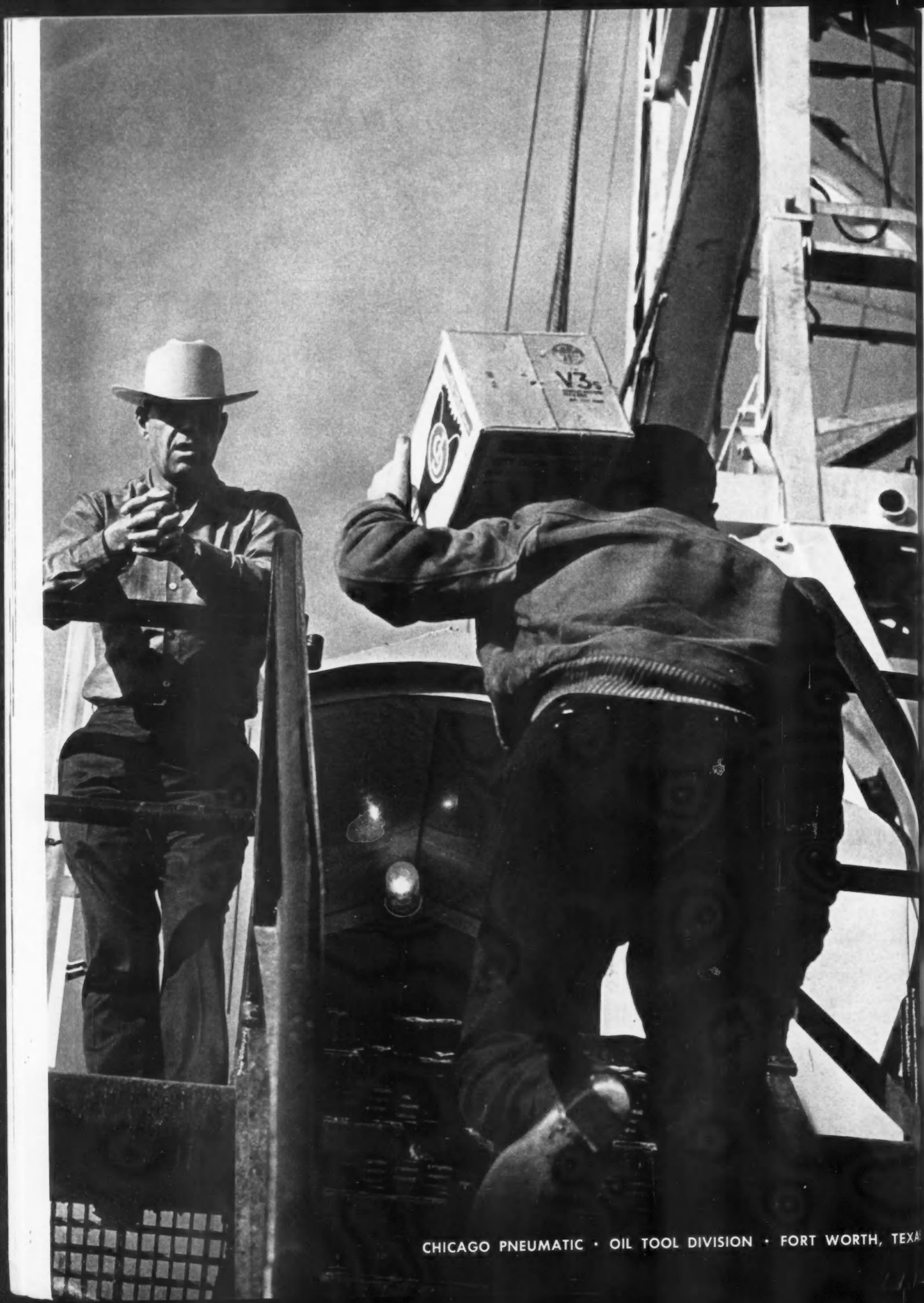

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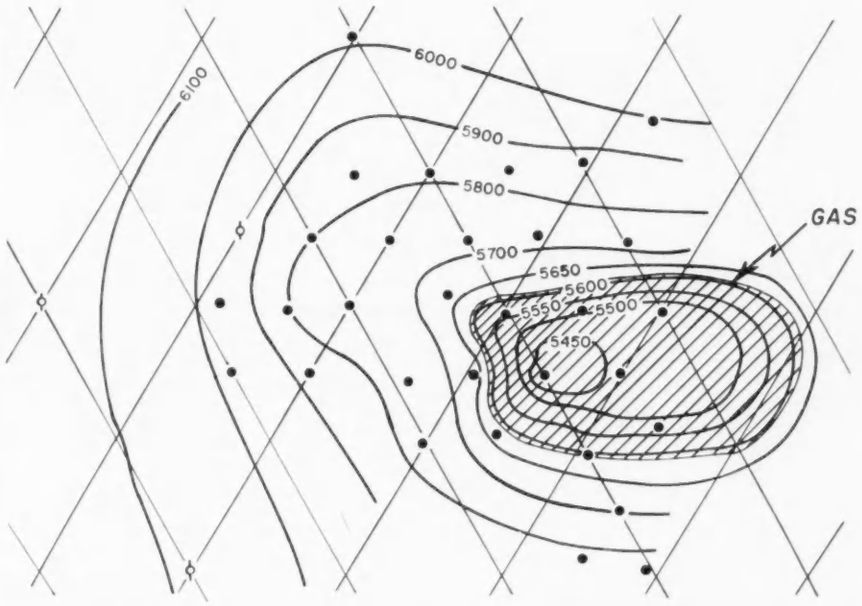


FIGURE 1—Gas reservoir in Telisa limestone in Radja field lies at crest of textbook-type anticlinal closure at about 5,500 feet subsea. There is about 175 feet of gas column in the Telisa. About 550 feet of closure is indicated by oil wells shown.

Natural gas utilization to begin in south Sumatra

By H. P. Dunn, Petroleum Engineer
Standard-Vacuum Oil Company
White Plains, N. Y.

NATURAL GAS RESERVES in the Radja oil field, located near Palembang in Standard-Vacuum Oil Company's operating areas in south Sumatra will commence utilization, upon completion of a fertilizer plant in the vicinity. Gas will be moved to the new plant via a 60-mile, 10-inch pipe line. This plant may lead to additional petrochemical industry development and to increase utilization of natural gas in Indonesia.

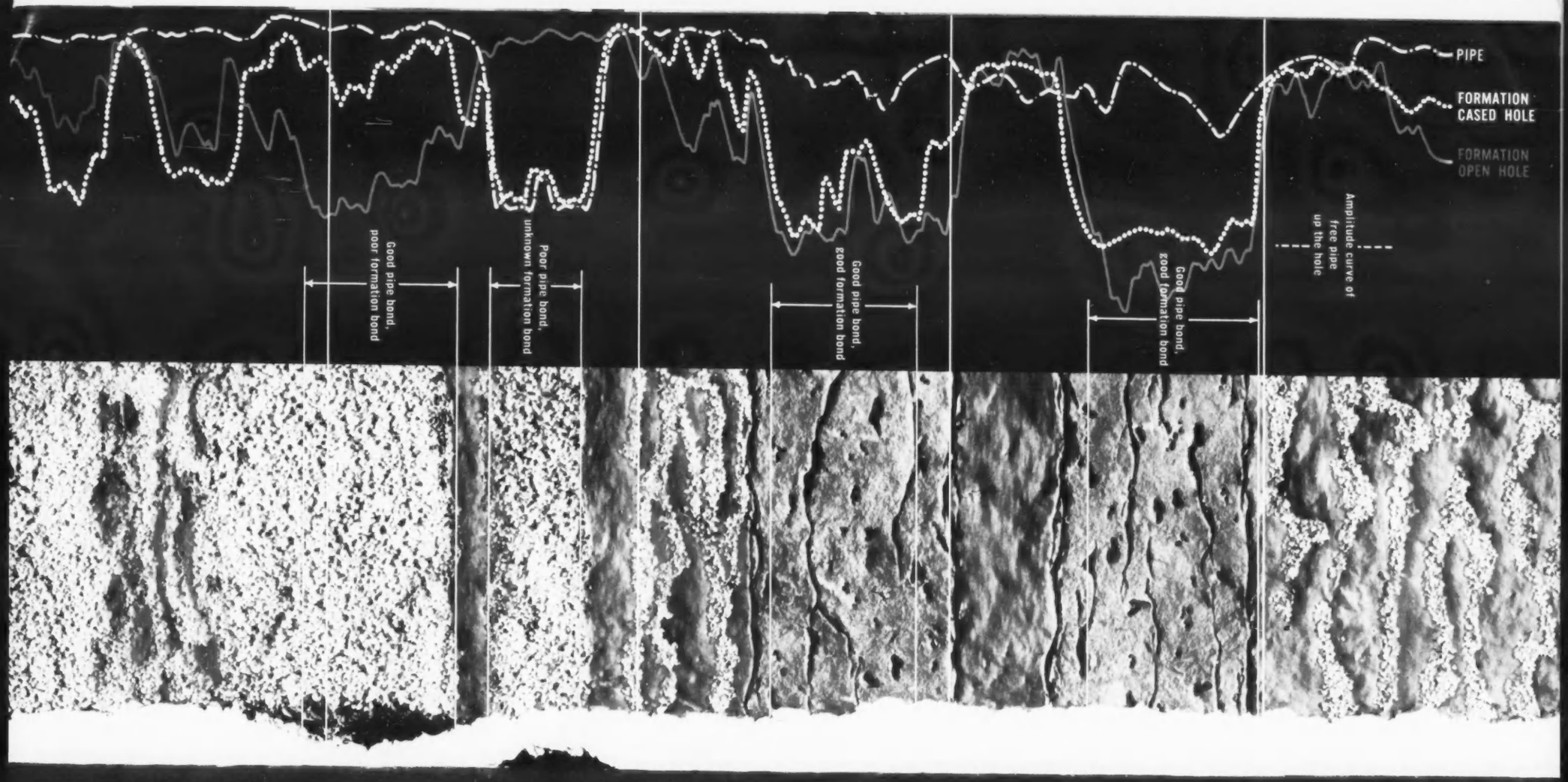
Radja field is located in Stanvac's Radja 5-A development contract block in south Sumatra. In 1922, Stanvac brought in its first sizable oil production from the Talang Akar field of south Sumatra after exploring in Indonesia since 1912. Various other fields in south and central Sumatra were discovered during subsequent years, including Radja field in 1940.

The Radja field is located on the crest of an anticlinal structure which contains 59 hydrocarbon-bearing reservoirs from 5,400 to 7,400 feet deep. About half of the reservoirs contain crude oil and condensate while others contain condensate only. Most of the reservoirs are connected to aquifiers.

Production. Thirty-one productive wells had been drilled in the field at the end of 1960, as shown on the general field structure map (Figure 1). Of these, 17 were producing 1,100 barrels per day of crude oil at the end of 1960. The primary producing reservoir is the E sand.

The Telisa limestone, which will be the primary source of the fertilizer plant gas, is at a depth of about 5,700 feet. It contains at reservoir conditions a very wet, non-retrograde gas having approximately one percent carbon dioxide. The formation is a medium porosity limestone with an average permeability of 70 millidarcys. A water drive should prove effective when the formation is placed on active production.

Gas for the fertilizer plant will be supplied from two main sources, the Telisa limestone and the gas outlet of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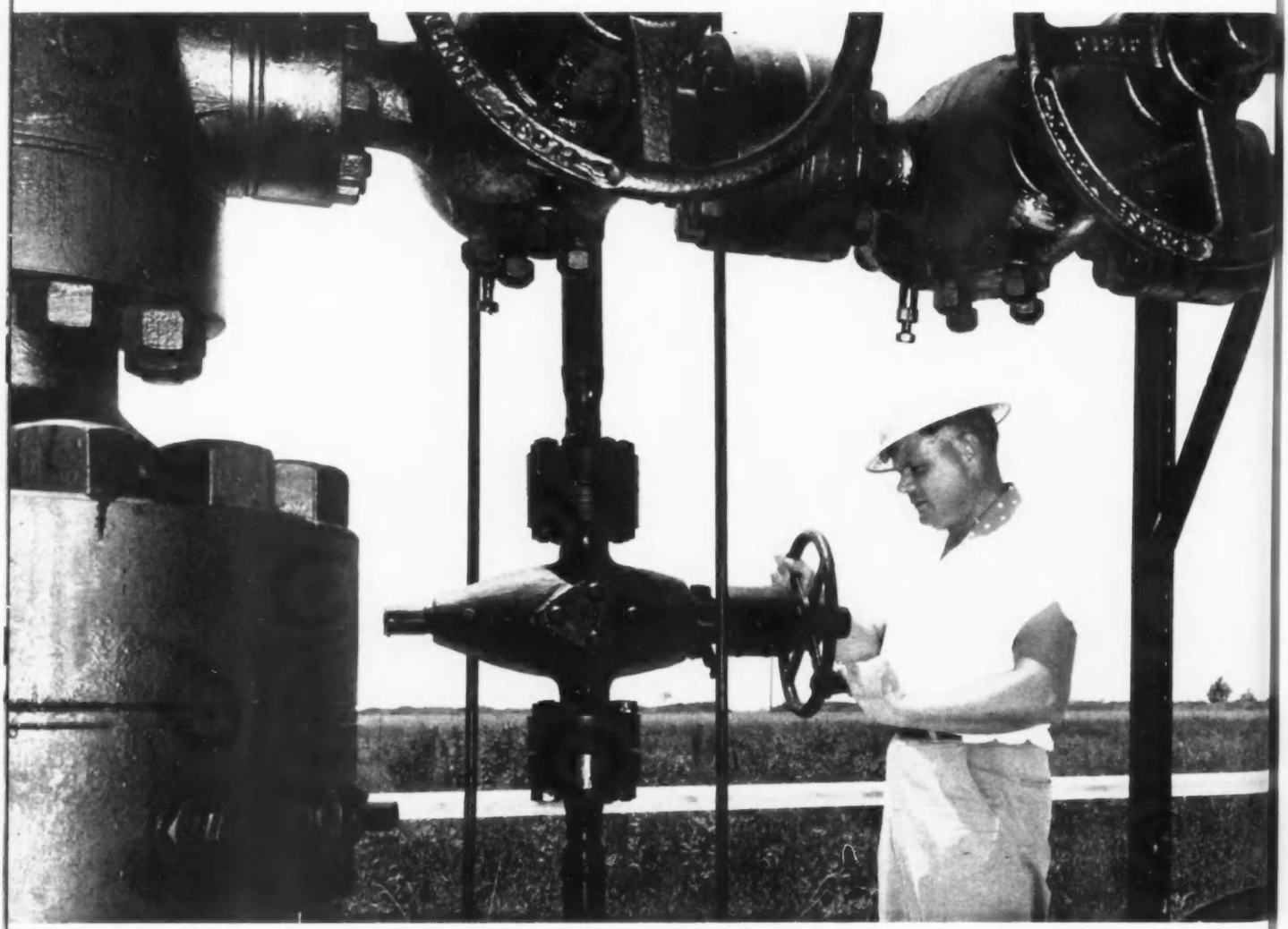

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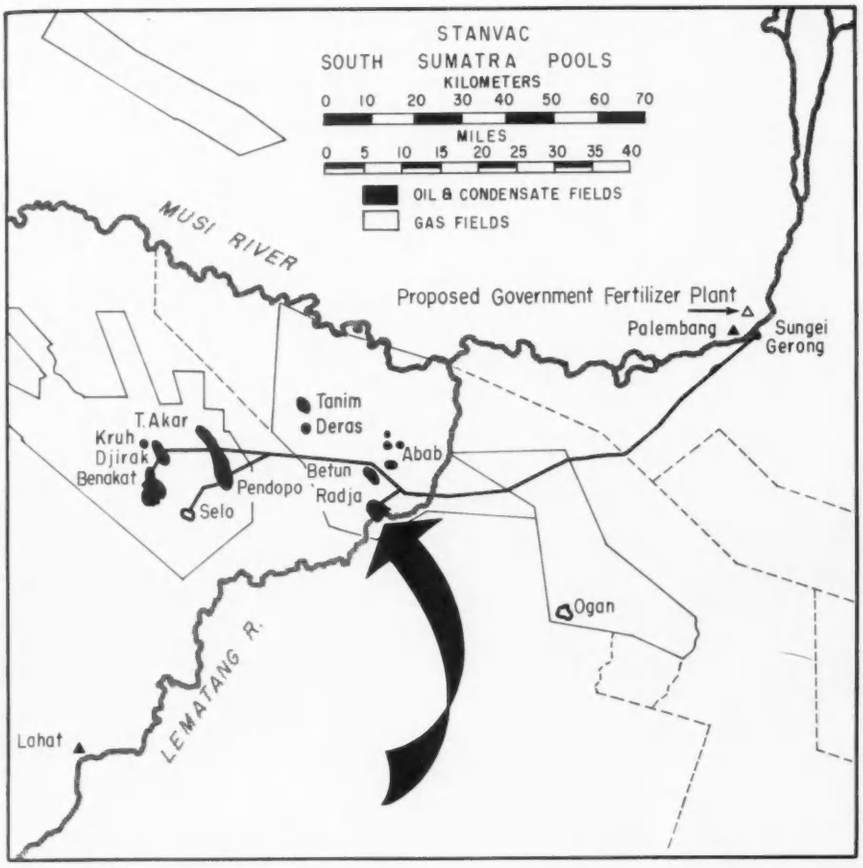

FIGURE 2—Map shows Standard-Vacuum Oil Company development blocks in south Sumatra. New 10-inch pipe line to carry Radja field gas to proposed government fertilizer plant near Palembang is expected to parallel existing crude oil lines.

the first stage (690 psi) solution gas separator of the Radja field crude oil processing station. Except for a small amount of production for gas injection into the Talang Akar field, the Telisa limestone has been shut in since its discovery.

The crude oil separator gas will provide about 28 percent of the total required with most of the remainder being taken from the Telisa along with lesser amounts from various other gas reservoirs in the field. At the end of 1960, only one well was producing from the Telisa as a source of injection gas. Three additional wells were to be drilled and some workovers performed before the Telisa and the other gas reservoirs are able to fulfill their portion of the fertilizer plant gas commitment.

Both the crude oil separator gas and Telisa gas contain large quantities of natural gasoline. Telisa gas, after being stripped in a high pressure separator, will be joined with the crude oil separator gas for further stripping and drying.

Two processes were being considered for natural gas recovery and dehydration. One is the ammonia absorption refrigeration system in which the gas is chilled to about 0° F, dropping out the gasoline and water. The other is the short cycle dry dessicant system in which gasoline and water are adsorbed onto dry dessicant beads which are then processed for liquid recovery. Either process would be feasible. The liquid recovered from the Telisa gas separator and one of these two processes will then be stabilized for storage and introduction into the crude stream.

Pipe line facilities. As shown on the general area map (Figure 2), 60 miles of 10-inch pipe must be laid by Stanvac to transport gas from Radja to the fertilizer plant. An entrance pressure of about 300 psi is calculated to be sufficient for delivery of a maximum daily rate of 15 million cubic feet and a minimum rate of 12 MMcfd.

The new gas line was expected to follow the route of crude oil lines which connect Stanvac's south Sumatran producing fields with the Sungei

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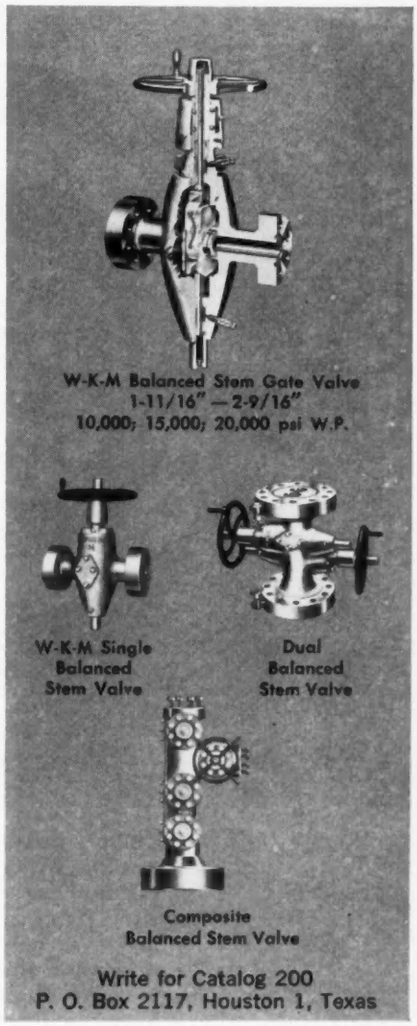
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Gerong refinery near Palembang. Where the line is to be laid along river banks, existing dikes will be used with the line supported above ground on concrete skids over "H" type pipe driven supports.

Three river crossings will be required: The Lematang which is 330 feet across, the Ogan (1,120 feet) and the Musi (1,370 feet). The Lematang crossing will use extra strong pipe which will be coated and wood sheathed and buried in both banks of the river. Extra strong pipe will also be used in the Ogan and Musi crossings but will be tape-coated and sheathed in concrete. The pipe will be buried in both river banks and, in the Musi crossing, will also be buried in the river bottom.

How the project developed. On February 20, 1959, a contract was signed by which Stanvac will supply 13.7 million cubic feet of gas per day from Radja field to a fertilizer plant at Palembang.

The plant is important to the Indonesian government and to Stanvac for two reasons. First, it will supply 100,000 tons per year of urea fertilizer which is badly needed by Indonesia to increase output of food and export crops. Step-up of local food production will decrease and (possibly) eventually eliminate present food imports which are a drain on the Indonesian economy.

Second, by using the Radja gas to make urea, the government will introduce the first petrochemical unit to be installed in the country. Considering the oil producing capacity of Indonesia and its oil and gas reserves (both discovered and probable) the Palembang plant may well lead the way to increased local utilization of these reserves in the manufacture of other needed petrochemicals.

Indonesia has a severe balance of payments problem. Any profitably operated local manufacturing enterprise will yield substantial benefits to the country due to decreased reliance on imports.

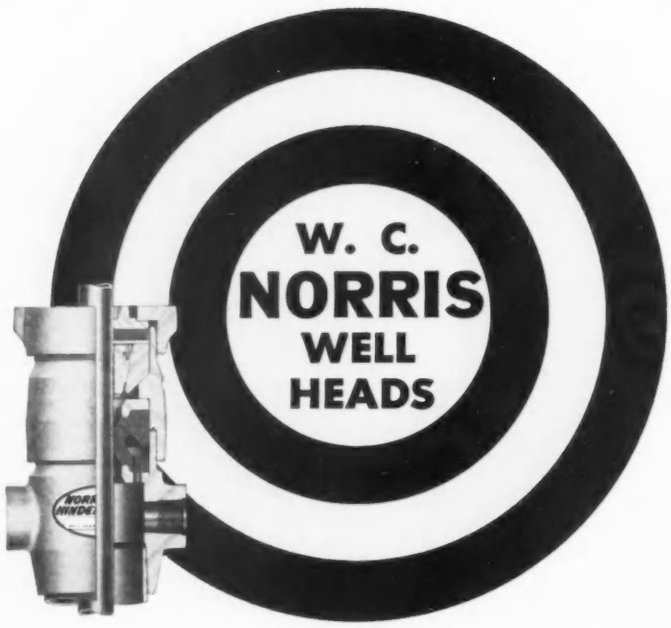
The fertilizer plant project results from the coordinated efforts of many diverse international organizations to build a much-needed manufacturing enterprise in a basically underdeveloped country. A loan was secured by the Indonesian government from the Export-Import Bank. A contract was signed with Stanvac and negotiations were being conducted to select a contractor to build the plant and train operators.

It is hoped that the Palembang fertilizer plant will be ready to receive gas late in 1962 or early in 1963. Gas line construction will probably begin during the latter part of 1961.

—The End

About the Author

H. P. Dunn is a petroleum engineer with Standard-Vacuum Oil Company. He received his degree in petroleum engineering from the Colorado School of Mines in 1953. His oil industry experience in the field has been with Stanvac in Indonesia. Dunn completed a year's special assignment at Stanvac's international headquarters at White Plains, N.Y., during the latter part of 1960, before returning to field work in Sumatra.



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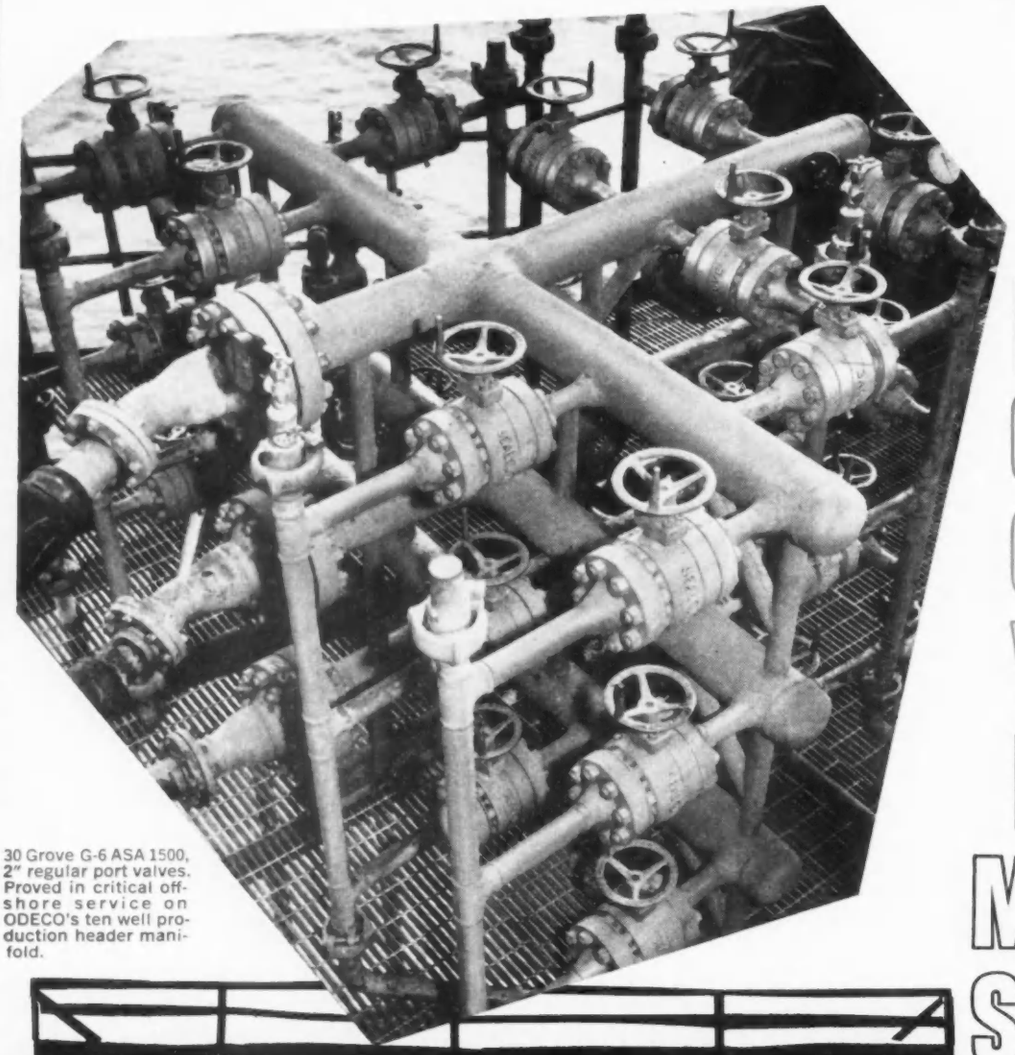

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7– 9	Alberta Society of Petroleum Geologists and Geological Association of Canada Convention, Calgary, Alta.
13–15	Louisiana-Arkansas Division of Mid-Continent Oil & Gas Association Thirty-ninth Annual Membership Meeting, Roosevelt Hotel, New Orleans.
13–15	National Petroleum Association, Annual Meeting, Traymore Hotel, Atlantic City, N.J.
17–20	AIEE Annual Electrical Conference on the Petroleum Industry, Jung Hotel, New Orleans.
20–	API Executive Committee of the Board of Directors, Greenbrier Hotel, White Sulphur Springs, W. Va.
24–26	Empire State Petroleum Association Fall Meeting, Sagamore, Lake George, N.Y.
24–27	ASME, Petroleum Mechanical Engineering Conference, Hotel Muehlbach, Kansas City, Mo.
25–27	Texas Mid-Continent Oil & Gas Association Forty-second Annual Meeting, Texas Hotel, Fort Worth.
27–29	Corrosion Short Course, Sponsored by Central Oklahoma Section of NACE and University of Oklahoma, University of Oklahoma, Norman.
Oct. 4– 6	AAODC Twenty-First Annual Meeting, Rice Hotel, Houston.
4– 6	ASME, Process Industries Conference, Shamrock-Hilton Hotel, Houston.
4– 6	NACE Western Regional Conference Benson Hotel, Portland, Ore.
8–11	SPE of AIME Thirty-sixth Annual Fall Meeting, Memorial Auditorium, Dallas.
9–11	NACE North Central Regional Conference, Chase Park Plaza Hotel, St. Louis, Mo.
15–17	National Association of Oil Equipment Jobbers Eleventh Annual Convention and Trade Show, Mayflower Hotel, Washington, D.C.
18–20	Sixteenth Annual Convention of the Rocky Mountain Oil & Gas Association
18–21	AAPG, Mid-Continent Regional Semi-Annual Meeting, Amarillo, Texas.
18–21	AAPG Pacific Section Regional Meeting, Los Angeles.
23–26	The Metallurgical Society of AIME Fall Meeting, Pick Fort Shelby Hotel, Detroit.
23–27	ASM Metal Show, Cobo Hall, Detroit.
24–27	NACE South Central Region Conference and Exhibition, Shamrock-Hilton Hotel, Houston.
25–27	Association of Geological Societies, Gulf Coast Section Annual Meeting, San Antonio, Texas.
29–31	Independent Petroleum Association of America, Annual Meeting, Shamrock-Hilton Hotel, Houston.
Nov. 1– 3	AAPG, Southwestern Federation of Geological Societies, 4th Annual Meeting, El Paso.
2– 3	SPE of AIME, 32nd Annual California Regional Meeting Hacienda Motel, Bakersfield.
2– 4	Geological Society of America Annual Meeting, Cincinnati.
5– 9	SEG Annual Meeting, Denver.
13–15	API 41st Annual Meeting, Conrad Hilton Hotel, Chicago.
15–	API Board of Directors, Conrad Hilton Hotel, Chicago.
26– thru Dec. 1	ASME Winter Annual Meeting, Statler-Hilton Hotel, New York.
27– Dec. 1	NACE Southeast Region Conference, Key Biscayne Hotel, Miami.

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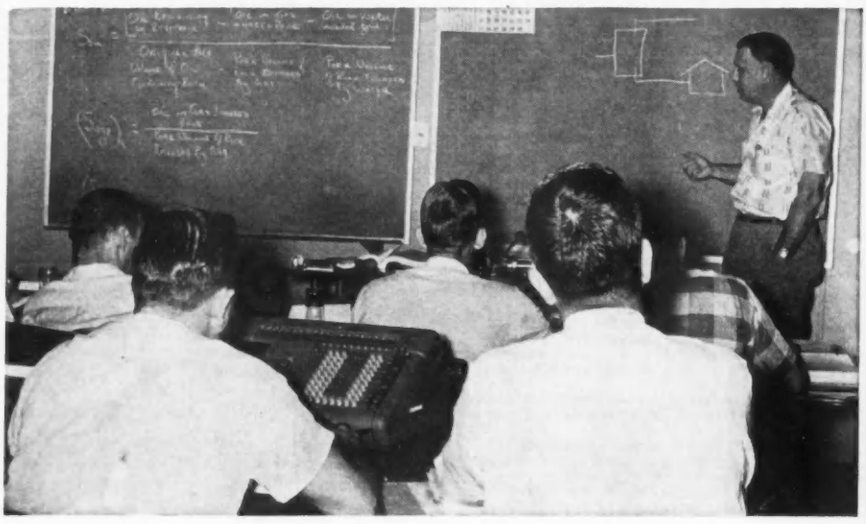
MIDLAND, TEXAS—Lucocus Serv.....MU 2-8311
NEW IBERIA, LA.—Cardinal Wireline...EM 4-5165
Klein Deco-Wire Line.....EM 4-0471
ODESSA, TEXAS—Kuykendall Wireline..FE 7-7210
OKLAHOMA CITY, OKLAHOMA
Rainbo Service Co.....ME 4-2131, ME 4-0105
PETTUS, TEXAS
Eddie Jones Eng. Co. Pettus 16-Beeville FL 8-1218
VICTORIA, TEXAS—Camco, Inc.....HI 3-9251
WICHITA FALLS, TEXAS
Eads Eng. Serv., Inc.....776-0931
WILLISTON, N. D.—C. A. White.....GR 3-6555
EDMONTON, ALBERTA, CANADA
Camco, Ltd.....GE 9-3641, GE 9-3124
VENEZUELA:
Anamie Anzoategui—A-Z Export, S.A.
Maracaibo—A-Z Export, S.A.....6982-3480
Puerto La Cruz—A-Z Export, S.A.....86-332
Anzoategui W. L. Service..24-353

Your industry at work

A monthly roundup of items of interest about people, companies and associations



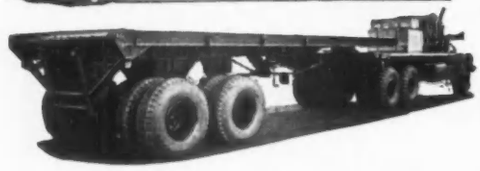
Tidewater Employes Study Reservoir Engineering

Tidewater engineering personnel from production districts across the United States and Canada recently completed a three-week reservoir engineering school. Emphasis was on the industry's increasing attention to supplemental energy drives, including such techniques as thermal combustion and carbon dioxide injection. The course was conducted by Tidewater's Southern Division in Houston and was presented by Petroleum Engineering Department faculty members from Texas A&M College.

oilfield transporting equipment

OILFIELD TRUCK AND FLOAT
Thornycroft Sandmaster 252" wheel base Oilfield Truck. Hands-England full Oilfield Body. 60,000 lb. winch, heavy duty gin poles, winch operated gin pole risers and folding SAE king pin.
Hands-England 75,000 lb. capacity, tandem axle Oilfield Float 30'0" long and 9'6" wide, folding support legs and inverted 36" fifth wheel.
Truck and Float on Michelin 18.00 x 25. Sahara "X" sand tires.

OILFIELD FLOAT
Hands-England 75,000 lb. capacity tandem axle Oilfield Float 30'0" long and 8'6" wide, folding support legs and inverted 36" fifth wheel.
Float on 11.00 x 20—14-ply tires.



OILFIELD TRUCK AND FLOAT
Scammel Constructor 261" wheel base Oilfield Truck.
Hands-England 75,000 lb. capacity tandem axle Oilfield Float 30'0" long and 9'6" wide folding support legs and inverted 36" fifth wheel.
Truck and Float on 14.00 x 20—18-ply tires.

OILFIELD FLOAT
Hands-England 25,000 lb. capacity single axle Oilfield Float 24'0" long and 8'0" wide, folding support legs and SAE king pin 11.00 x 20—12-ply tires. Steel stake sides.

SUPPLIED BY

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Mobil International Realigns Operations Into 4 Regions

Mobil International Oil Company is realigning its operations by setting up four regions instead of three according to Herman J. Schmidt, president.

W. P. Tavoulareas

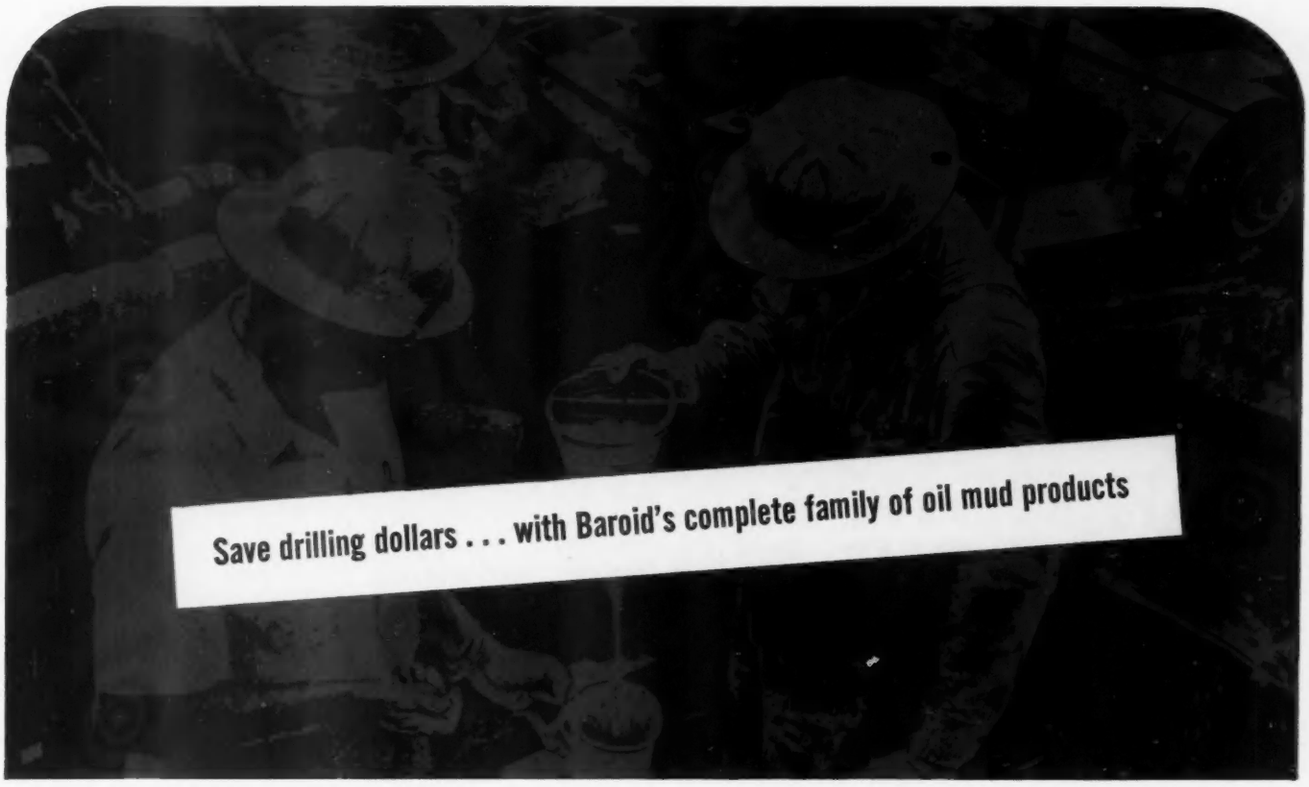
The new regions and regional vice presidents are: Inner Europe, Curtis M. Llaerner; Northern and Southeastern Europe, Arthur Lanckton; Latin America and Caribbean, Earl A. Brown, Jr., and Mediterranean and West Africa John C. Dean.

The regional vice presidents will report to Rawleigh Warner, Jr., executive vice president operations. Robert Siegal, also an executive vice president, continues responsible for Middle East concessionary interest.

William P. Tavoulareas has been named vice president for plans and programs, a new position.

Gulf Moves Exploration Headquarters to Florida

Gulf Oil Corporation has moved the headquarters of its newly named Western Hemisphere Exploration Division, formerly known as the New York Ex-



Baroid Field Report: Los Angeles County, California. This case history exemplifies the application of one type of a Baroid Oil Mud used to solve this particular problem.

Baroid Oil Mud solves water-sensitive pay sand problem

A Baroid Oil Mud containing INVERMUL*, PETROTONE** and DURATONE** was recently used successfully to prevent water damage to productive oil sands in the Inglewood Field, Los Angeles County, California.

The water-sensitive formations and high bottom-hole temperatures encountered had previously prevented completing below 7,500 feet without water damage. These difficulties were attributed to formation damage by the filtrate from conventional water muds.

The well was spudded and 16" casing set at 550 feet. An AQUAGEL*-caustic soda-CARBONOX* emulsion mud was used to drill to 3,000 feet—10¾" casing set. The AQUAGEL-CARBONOX mud was treated with TRIMULSO* and used to drill to 7,400 feet. At 7,400 feet the oil-in-water-emulsion mud was displaced with a pre-mixed Baroid Oil Mud containing INVERMUL and DURATONE. No difficulty was encountered during the displacement. Water mud incorporated into the oil mud did not alter its flow properties.

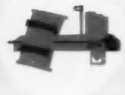
PETROTONE (2 lb/bbl) was used to treat this oil mud to eliminate the possibility of any settling of BAROID* at the high bottom-hole temperature.

DURATONE controlled filtration at 0.0 to 0.5 ml, all oil. This control insured against filtrate damage to formations.

Baroid Oil Muds, product of Baroid research and engineering, saves your drilling dollars and keeps your drilling program on schedule. For more information on the unique properties and flexibility of Baroid Oil Muds write for Product Data Sheets.

6117

BAROID



BAROID DIVISION NATIONAL LEAD COMPANY
MAIN OFFICE: P. O. BOX 1675, HOUSTON 1, TEXAS

BAROID--*Still Pioneering Drilling Mud Research • Engineering • Marketing*

*INVERMUL, emulsifier; AQUAGEL, bentonite; BAROID, weight material; CARBONOX, thinner; TRIMULSO, surfactant; are Registered Trademarks of Baroid Division National Lead Company.
**PETROTONE, suspending agent, and DURATONE, filtration stabilizer, are Trademarks of Baroid Division National Lead Company.

ploration Division, to Coral Gables, Fla. The transfer was to increase operating efficiency in its Latin American operations.

According to T. A. Kibby, division manager, the move will permit closer and faster liaison with exploration operations in Central and South American countries where Gulf is now active. In addition to exploration activities in Panama, Peru, Costa Rica, British Honduras and the Bahamas, Gulf has recently made an oil discovery in Bolivia and is currently drilling two additional wildcat wells.

Twenty-six employes were transferred to Florida.

Men in the industry

Herman P. Pressler, Jr., vice president for public relations, **Humble Oil & Refining Co.,** has announced the following assignments in the Houston office:

Edward Littlejohn has been appointed manager of the public relations department.

Assisting Littlejohn will be five key advisory and supervisory personnel.

A. B. Penny has been appointed public relations adviser.

George A. Lloyd, has been appointed head of the section on citizenship training, highway traffic, and communications.

Walter G. Beach has been appointed head of the publications and information distribution section.

Jay H. Rose has been appointed head of the press relations and special writing projects section.

John P. Shannon has been appointed head of the general public relations services section.

G. A. Mabry has been appointed public relations manager of **Humble Oil & Refining Company's** Southwest Region. At the same time, **R. R. Thompson** was appointed research coordinator in the Research Department in the company's Houston headquarters.

Thomas S. Gates, chairman of the Executive Committee of Morgan Guaranty Trust Co. of New York, has been elected a member of the board of directors of **Cities Service Co.**

T. S. Gates

C. A. Herter, Jr.

Christian A. Herter, Jr., will join **Socony Mobil Oil Company, Inc.,** in September. He will advise the company on government relations and the state, federal and international levels.

P. M. Konkel, assistant chief geologist for **The Ohio Oil Company** at its domestic production headquarters in Findlay, Ohio, has become division geologist in the newly expanded Tulsa Production Division.

Theo N. Law, executive vice president and founder of **Falcon Seaboard Drilling Company,** has been elected to the new position of chairman of the board of directors, serving as chief executive officer of the company. Other elections include **C. W. Alcorn,** executive vice president in charge of the Gulf Coast operations, elected to the new position of vice chairman of the board of directors, and **J. L. Stauss,** executive vice president at the firm's general offices in Tulsa, was elected president.

Kenneth A. Scott has been appointed manager of Intelligence in the Commercial Development Division of **Sun Oil Company's** Research and Engineering Department. Scott will be responsible for advance information and evaluations of developments in science and

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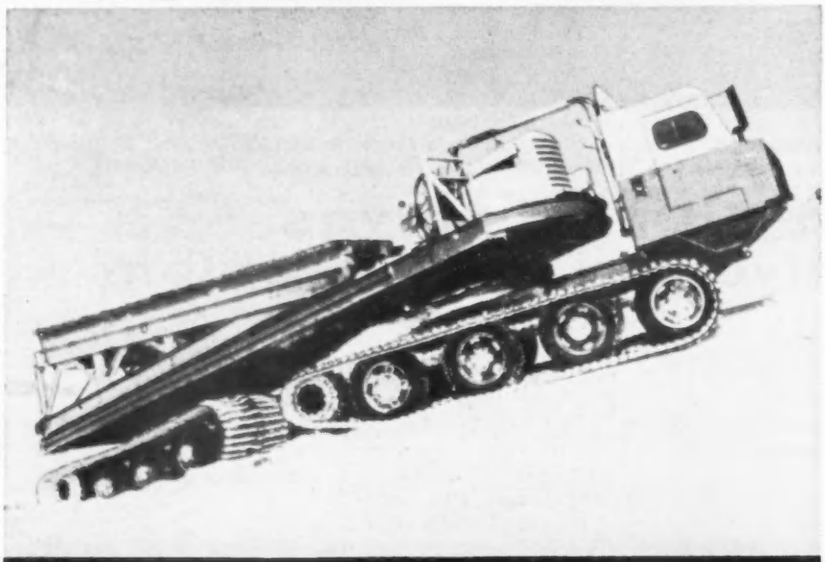

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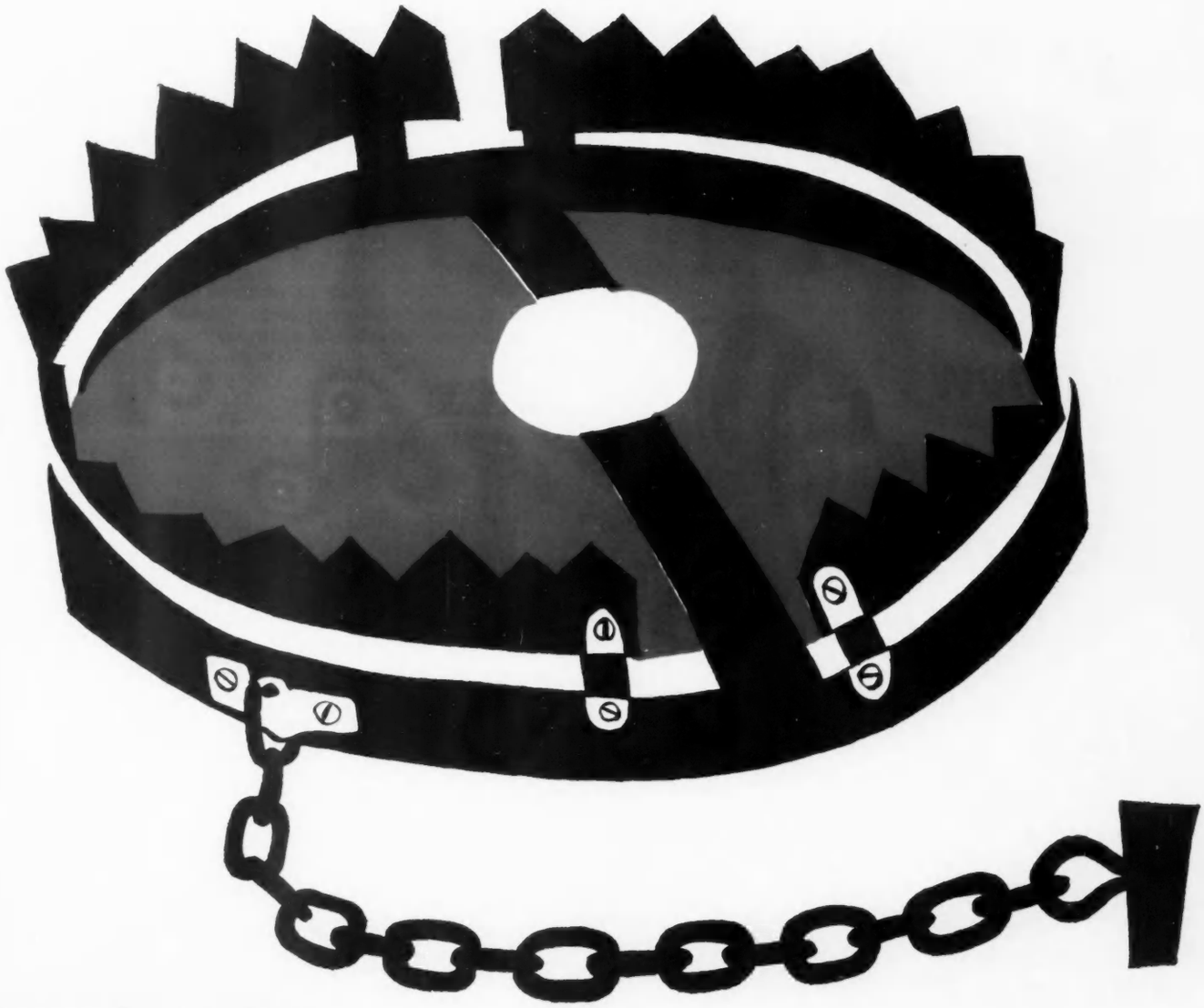
THE CARRINGTON COMPANY



acts fast: There are times when a valve must shut off NOW! That's why you'll find Rockwell-Nordstrom valves in critical operations everywhere. With their smooth, fast quarter turn action and positive shut-off they're man's best friend in an emergency. It makes a lot of sense to use these same Rockwell-Nordstrom valves in all services—they cost no more. We'll be happy to send you complete information.

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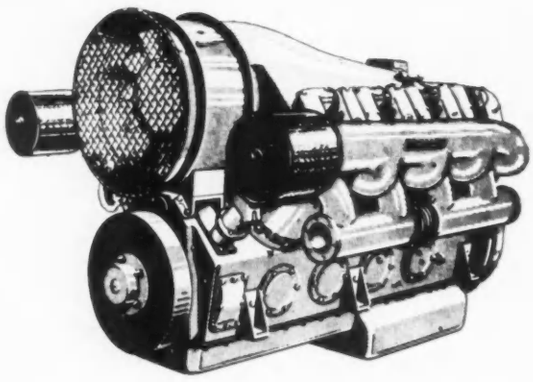
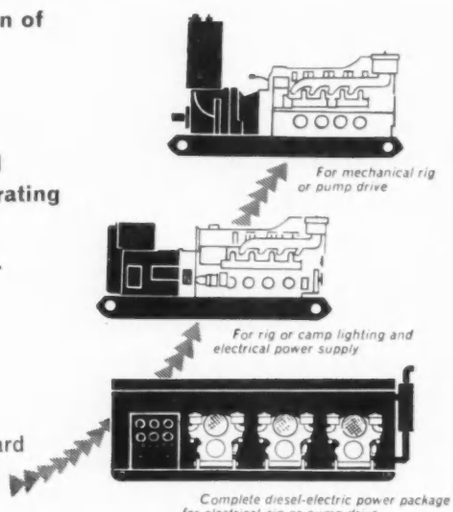


Here are seven good reasons why the Paxman 'Vega' air-cooled diesel cuts costs for the drilling contractor:

- ★ **Less initial cost, by elimination of radiator and accessories.**
- ★ **No water supply problems.**
- ★ **No freezing problems.**
- ★ **Constant top performance and dependability—whether operating in the tropics or the Arctic.**
- ★ **Light and easily transportable.**
- ★ **Low maintenance.**
- ★ **Long Life.**

And now, the 'VEGA' is factory-engineered into three standard packaged units for specific power requirements in the oilfields.



Complete diesel-electric power package for electrical rig or pump drive

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air-cooled diesels 230-610 b.h.p.

These advanced-design diesels are backed by the world-wide Paxman after-sales service which means men and spares whenever and wherever you want them.

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a member of the RUSTON *Group*

Men in the industry

technology from government and industrial sources. At the same time, **John H. McWilliams** was elected assistant secretary of Sun Oil.

John H. Atwood

John H. Atwood has joined **Global Marine Exploration Company** to represent the company in the Gulf Coast area. Before joining Global Marine, Atwood was supervising all of Sohio Petroleum Company's drilling operations, both foreign and domestic. Atwood will headquarter in Houston and be Gulf Coast manager for the firm.

Walter D. Floersheimer and **William H. Gregory, Jr.,** have been elected directors of **Siboney-Caribbean Petroleum Company.** Other directors re-elected were: **George Z. Fencil, W. H. Garbade, W. F. Styler, Jerome F. Tegeler** and **Graham Walker.**

W. A. Bramlette, formerly assistant manager of **Humble Oil & Refining Company's** Exploration Department in the company's Central Region in Tulsa, has become coordinator of special studies. **W. M. Rust, Jr.,** formerly assistant chief geophysicist in the Southwest Region, has become coordinator of department services.

W. J. Zeman

L. G. Minter

William J. Zeman has been elected vice president and general counsel and a member of the executive committee of **Phillips Petroleum Company. Lloyd G. Minter** was elected general attorney. Zeman succeeds **Rayburn L. Foster** who has retired, and Minter succeeds Zeman.

Dr. William E. Bradley, director of research for **Union Oil Company of California,** has been elected a vice president of the company. Dr. Bradley will continue to direct research.

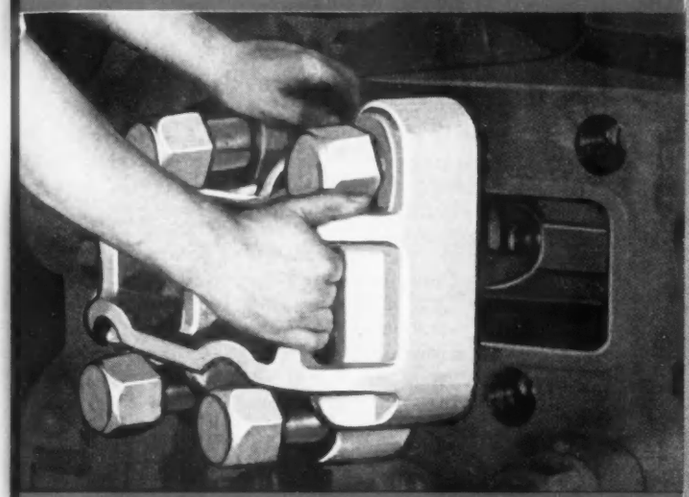
E. L. Smith, district landman at Midland, Texas, has succeeded the retired **Carl W. Krouse** as Houston Division landman for **The Ohio Oil Company.**

Ross H. Faulkner has joined **Mobil Oil Company** as acquisitions advisor to the vice president for exploration and pro-

WHEN YOU BUY BLOWOUT PREVENTERS

GET SHAFFER "SWING OPEN" DOOR DESIGN... IT SIMPLIFIES RAM CHANGES!

WHAT IT IS: With Shaffer Blowout Preventers each ram is readily accessible by simply unbolting and swinging open a convenient door... a *side*-opening door in the Shaffer Type B and Type E Blowout Preventers—an *end*-opening door in the Shaffer Type XHP and Type LWS Blowout Preventers. Only Shaffer equipment offers this important design advancement!



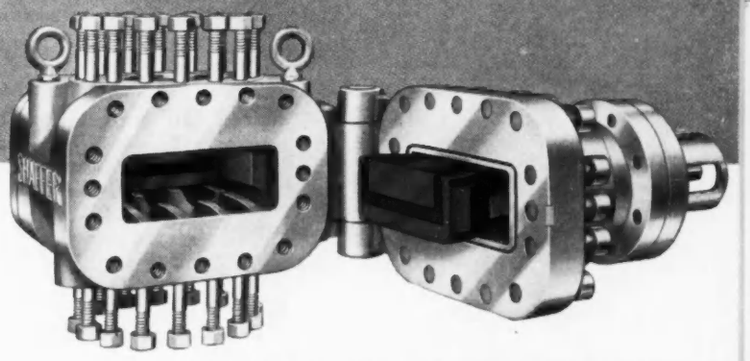
SHAFFER TYPE B AND TYPE E PREVENTERS FEATURE SIDE-OPENING DOORS FOR RAM CHANGES

WHY IT'S BETTER: As a drilling program progresses, it is necessary to change blowout preventer rams whenever the size of the drill pipe is changed. This sounds like a relatively quick and simple operation. And it *is* with Shaffer Blowout Preventers because of their "Swing-Open" door design. But this is not true of *all* blowout preventers...

In blowout preventers that do not have quick-access doors, changing the rams—or checking the ram compartments—can be a complicated, time-consuming operation. In many cases, a major portion of the control gate assembly must be dismantled in order to gain access to the ram compartments—particularly those in the lower unit of a two unit hook-up.

Also with other units, hydraulic lines often must be disconnected, resulting in loss of hydraulic fluid and further complications in the over-all operation—plus the ever-present risk of not properly reconnecting the lines.

But not with Shaffer Blowout Preventers!



SHAFFER TYPE XHP AND TYPE LWS PREVENTERS FEATURE END-OPENING DOORS FOR RAM CHANGES

THE "SWING-OPEN" DOORS IN SHAFFER UNITS

...assure quick, easy access to the ram compartments whenever desired. Moreover, with Shaffer design it is not necessary to break hydraulic lines to open the gates... no fluid is lost... and there's no risk of inadvertently leaving a line "open" (or not properly re-connecting the fittings).

Simply unbolt and swing open the doors. Change rams. Close and bolt the doors shut again. It's that simple!

And the safety and convenience of "Swing-Open" door design is just one of the many "plus" advantages built into *every* Shaffer Blowout Preventer!*

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TYPE B AND TYPE E PREVENTERS are the units selected for most drilling applications. Type B has *non-rising* Locking Shafts for maximum compactness... Type E has *rising* Locking Shafts for quick indication of ram position.

TYPE XHP PREVENTERS are ideal where extra-high well pressures are a problem. Each XHP unit is individually tested to 15,000 PSI Working Pressure in 7 1/16" Bore Size... to 10,000 PSI Working Pressure in 9" and 11" Bore Sizes.

TYPE LWS PREVENTERS combine lightweight with adequate pressure rating for a wide range of applications. LWS units weigh approximately *half* as much as other Preventers of comparable size!

The above Preventers (except Type XHP) are available in choice of Double units (*two* Preventers unitized into *one* compact body for maximum space-saving)—or Single units.

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- Positive "In-Line" Power Drive!
- Space-Saving Compactness!
- Self-Cleaning Ram Compartments!
- Completely Enclosed Construction!
- "Floating" Ram Design!

...and still others your Shaffer representative will gladly explain to you!

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ducing, with headquarters in New York. Faulkner will assist in the acquisition of producing properties.

A. K. Haggard, superintendent of operations for **BBM Drilling Company,** Houston, has been made a director of the firm.

Dr. Albert W. Musgrave, computer designer and now a **Mobil Oil Company** geophysicist, has been named the 1961 recipient of the **Colorado School of Mines van Diest Gold Medal.**

William G. McKnight, Jr., general partner, Eastman Dillon, Union Securities & Co., New York, has been elected to the board of directors of **Tidewater Oil Company.**

G. B. Burris has been appointed vice president and general manager of **Ray Smith Drilling Company,** Dallas and Midland, Texas.

Scott A. Murray

Scott A. Murray has been appointed executive vice president of **International Drilling Company,** whose offices are located in Rome, Italy, London, England, and The Hague. Murray will be headquartered in the Rome offices.

V. G. Harrison has been named manager of **Shell Oil Company's** Industrial Relations on the West Coast, succeeding **A. F. Smith.** Harrison will headquarter in Los Angeles.

V. E. Schermerhorn has been appointed supervisor of the newly established Western District Crude Oil Supply office of **The Standard Oil Company (Ohio),** located in Oklahoma City.

J. R. Kyle, chief of foreign geophysical operations, **Humble Oil & Refining Company,** Tulsa, has been appointed to the Humble headquarters exploration staff in Houston, headed by **Merrill W. Hass,** vice president, and under the direction of **W. M. Rust, Jr.**

Donald W. Franklin, district geologist in Midland, Texas, for **The Ohio Oil Company,** has been named assistant division geologist for the company's Houston Production Division.

Ed Fizer, vice president of **First National Bank of Fort Worth,** has been named manager of the bank's Oil and Gas Department.

E. Raymond Corey has been elected to the board of directors of **Helmerich & Payne, Inc.**

Associations

O. A. Melvin

W. M. Koehler

Houston District NACE Announces New Officers

O. A. Melvin, consulting engineer, Carboline Company, Houston, has been elected chairman of the National Association of Corrosion Engineers, Houston District. Other officers elected were Benton Russell, president of Russell & Sharpe, Inc., vice chairman, and W. M. Koehler, senior engineer, Humble Oil & Refining Company, Houston, secretary-treasurer.

Benton Russell

J. T. Adams Named to ASME Oil and Gas Power Committee

Joseph T. Adams has been appointed to the Executive Committee of the Oil and Gas Power Division of The American Society of Mechanical Engineers. Formerly an associate to the Executive Committee, Adams will serve in his new capacity for a five-year term.

Houston Geologists Announce New Officers

The Houston Geological Society has announced new officers for the 1961-1962 term. Those elected include: G. C. Hardin, Jr., president; Benjamin T. Simmons, first vice president; E. H. Rainwater, second vice president; Lewis J. Hubka, Jr., secretary; Cecil R. Rives, treasurer. W. R. Canada and W. F. Cooke, Jr., were elected to the advisory committee.

Lafayette Geological Society Names New 1961 Officers

The Lafayette Geological Society, Lafayette, La., recently named new officers. They are: Frank W. Harrison, Jr., consulting geologist, president; Jay Howell, Petroleum, Inc., vice president; Stuart Hastings, Phillips Petroleum Company, secretary, and D. C. (Dave) Archer, W.W.F. Oil Corporation, treasurer.

Executive committee members include S. A. Spencer, Phillips Petroleum Company, past president; James W. Sheller, State Exploration Company, and C. E. (Gene) Whipp, Trunkline Gas Company.

Well Log Analysts Elect New Officers

The Society of Professional Well Log Analysts has elected a new slate of officers with J. H. Blackburn, Sunray-Mid-Continent Oil Company named president.

Other officers elected include: J. D. Owen, Phillips Petroleum Company, vice president-Technology; E. S. Griffith, Sinclair Oil & Gas Company, vice president-Membership; A. V. Messineo, Atlantic Refining Company, vice president-Public Relations; C. R. Glanville, Jersey Production Research Company, secretary-treasurer; Dr. Floyd L. Cash, Arlington State College, editor, and H. Guyod, consultant, Houston, and R. J. Jones, consultant, Casper, Wyo., elected members-at-large.

Herschel Martin Heads Petroleum Accountants

Herschel C. Martin has been elected president of the Petroleum Accountants Society of Dallas.

H. C. Martin

Martin is controller, officer and director of companies in the Dallas office of Wrather Interests.

Other new officers are: Lionel E. Gilly, Producing Properties, Inc., vice president; Merlin E. Wiemers, Creslenn Oil Co., secretary; W. J. Westerlage, The Atlantic Refining Co., treasurer, and E. S. McLaughlin, Jr., Sun Oil Co., assistant treasurer.

J. P. Jones Re-Elected President of PGCOA

J. Paul Jones has been unanimously re-elected president and executive manager of the Pennsylvania Grade Crude Oil Association. Karney R. Cochran, Bradley Producing Corp., was re-elected first vice president and A. C. Simmons was re-elected second vice president.

Howells Named Chairman of Canadian Petroleum Association

Dr. W. C. Howells, Texaco Canada Limited, was named chairman of the Canadian Petroleum Association Board of Governors at the annual meeting held recently in Calgary. D. B. Furlong, Producers Pipelines Ltd., Regina, was elected first vice chairman, and W.D.C. Mackenzie, Imperial Oil Limited, was named second vice chairman.

The 1961 Board of Directors also were elected. They include A. F. Beck, Canadian Export Gas & Oil Ltd.; S. F. Bird, Mobil Oil of Canada, Ltd.; G. E. Dunlap, Sun Oil Company; A. E. Feldmeyer, Canadian Superior Oil Company; Furlong; K. H. Gibson, Pacific Petroleums Ltd.; C. Hay, Royalite Oil Company Limited; Howells; G. L. Knox, The California Standard Company; Macken-

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For both contractor and company, the blue ink on a *complete* Drilling Recorder chart helps put more "black" ink on the books. Today's competitive conditions demand maximum efficiency, in drilling, in supervision, in analyzing structures drilled.

On a single chart, Totco's 3-pen Drilling Recorder gives accurate, directly comparable data for penetration, weight in suspension, and torque or pump pressure. *Only Totco* "tells the hole story" so clearly, accurately and completely... minute by minute... foot by foot.

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In over two years of field service, the Totco Drilling Recorder has been thoroughly proved. On the Totco chart *every movement of the brake*... every change in weight is recorded permitting a detailed analysis of the time required for *every* operation. You can see weight on bottom at a glance. A torque record pinpoints tight spots or locked cones giving you a warning of possible trouble. Or, in lieu of torque, pump pressure may be recorded.

One driller, for example, noted on his chart that pump pressure gradually was dropping though pump operation had not changed. He pulled the string, found a hole in the pipe that soon would have caused a twist-off, saved anywhere from one to fifty thousand dollars in fishing costs.*

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zie; A. M. McLachlin, Shell Oil Company of Canada, Limited, Regina; F. C. Osment, Pan American Petroleum Corporation; G. T. Pearson, Hudson's Bay Oil & Gas Company, Limited; W. L. Powell, The British American Limited, Regina; E. W. Scott, Union Oil Company of California, and D. M. Tyerman, McPherson, Leslie & Tyerman, Regina.

South Central NACE To Meet in Houston

South Central Region of the National Association of Corrosion Engineers will hold its 1961 Conference and Exhibition October 24-27 in Houston's Shamrock Hilton Hotel. Information on the exhibition can be obtained from NACE, 1061 M&M Building, Houston.

Suppliers' notes

Walter J. Greer, vice president and director of research and engineering of **Welex, Inc.,** has been named chairman and chief executive officer of **Welex Electronics Corporation** and elected vice president of the **Halliburton Company,** the parent organization.

Edward W. Metters and **Curtis T. Deehr** have been appointed by **U.S. Steel's Oil Well Supply Division** as city representatives in Los Angeles. Other new appointments include **James C. Dendy** as assistant district engineer, production equipment, located in Shreveport, La., and **Billy E. Wright** as field representative in Andrews, Texas.

Pat Childs has been named vice president in charge of sales for the **Harold Brown Company.** Childs is a graduate of Texas A&M.

Pat Childs

David J. Gent

David J. Gent is in charge of the new district sales office opened in Dallas by **Hardy-Griffin Engineering Corp.**

Thomas Tefertiller has been appointed district manager of the Oil Tool Division of **Chicago Pneumatic's** Oklahoma District.

John A. Malsi has been appointed Central Region resale sales manager of **Worthington Corporation,** succeeding **F. J. Reardon,** who transferred to the company's Construction Equipment Division as Eastern Zone manager.

Jack Mershon has been named area sales manager for **C-B/Southern's** Mid-Continent District. Maintaining offices in Tulsa, Mershon's area includes the Mountain States, West Central States and Western Canada.

Anthony J. Ormsby has been appointed secretary-treasurer of **W. C. Norris Division, Dover Corporation** of Tulsa. Prior to joining W. C. Norris, Ormsby was associated with the accounting firm of Ormsby and Ormsby in Toronto, Can. During this association he also served as a consultant to the Energy Board of the Dominion of Canada.

A. J. Ormsby

Louis Early has been appointed a sales-service representative by **Oil Center Tool Company** at Odessa, Texas. He was previously a warehouseman for O-C-T at Shreveport, La.

Douglas M. Smith has been appointed marketing manager of the Mechanical Goods Division of **United States Rubber Company.**

SLASH SECONDARY RECOVERY COSTS

Drill fewer injection wells... Eliminate multiple strings

Camco invites you to save thousands of dollars in secondary recovery costs by drilling fewer injection wells and eliminating extra tubing required for concentric and multiple strings. Deplete multiple zones by selective waterflood injection **from a single tubing string** with

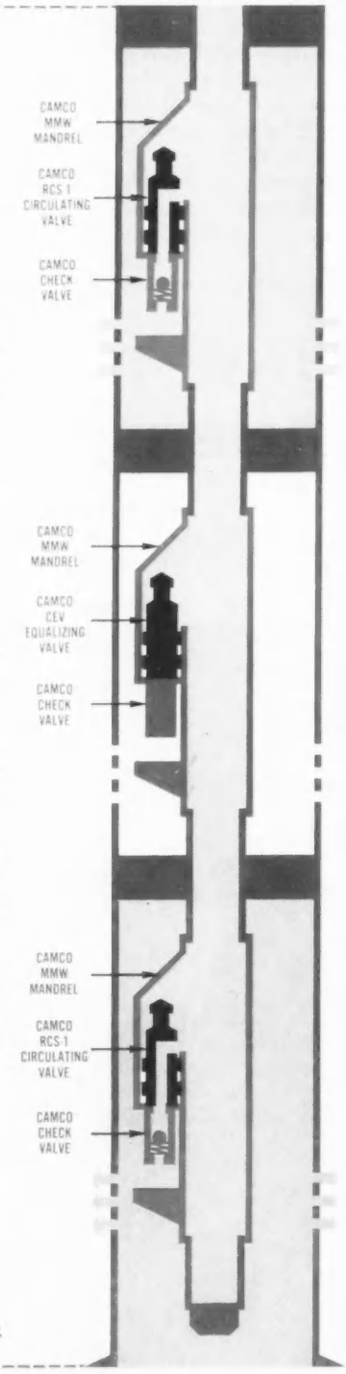
Camco MMW Waterflood Mandrels

Install Camco MMW Mandrel opposite each zone. Sidepocket design of Mandrel permits installation and removal of equipment by wireline and leaves tubing bore unobstructed.

Isolate zones with packers. Determine injection rates by spinner survey and inject into selected zones through Camco **RCS-1 Circulating Valves.**

To alter flow rate to any zone, change valve choke bean size. Blank off any zone with a Camco **CEV Equalizing Valve.** Camco **Check Valve** prevents back-flow feed between zones.

Up to 9 zones have been simultaneously waterflooded from a single tubing string with Camco MMW Mandrels at far less cost than that of conventional waterflood injection. Get full information from your Camco representative or write



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4

EASY WRENCHING
FAST MAKE-UP

3

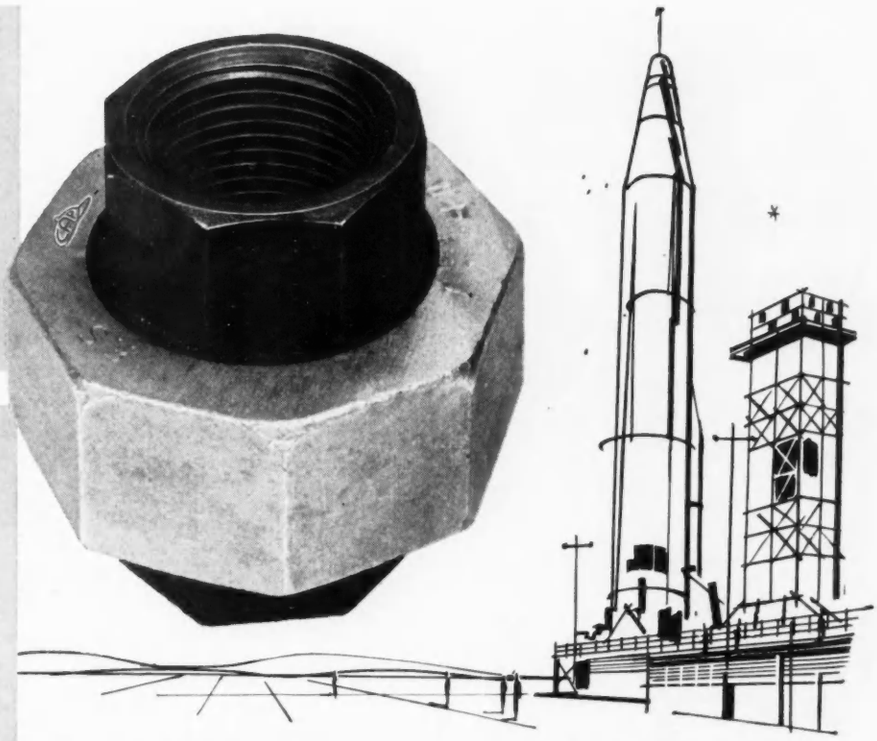
CLEAN/OVER-ALL PROTECTION

2

POSITIVE SEATING

1

LEAK-PROOF CONNECTIONS



Capitol count down

—INSURES NO FAILURES!

A union is more than a fitting. Installed, it is a refinery . . . a skyscraper . . . an atomic-energy plant! Continued operation depends on it.

And you can count on Capitol forged steel unions . . . because they give you 4-way service insurance.

(1) *Leak-proof connections* assured because Capitol unions have *more* threads, accurately cut and double-checked according to Army-Navy gauging practice. Both hand-tight and pressure-tight threads are checked, two operations instead of the one required for American Standard gauging. The extra threads mean on-the-job assurance of tight installations. (2) *Positive seating* because each union is individually pressure-tested. (3) *Clean/over-all protection*, each male and female part completely phosphate coated; each nut electro-zinc plated. (4) *Easy wrenching/faster make-up* because all three parts have a definite octagon shape.

You get all 4 important advantages at no extra cost when you specify CAPITOL forged steel unions . . . one of the full-line of Army-Navy gauged forged steel fittings. Now more than one million in service . . . and not a single failure.

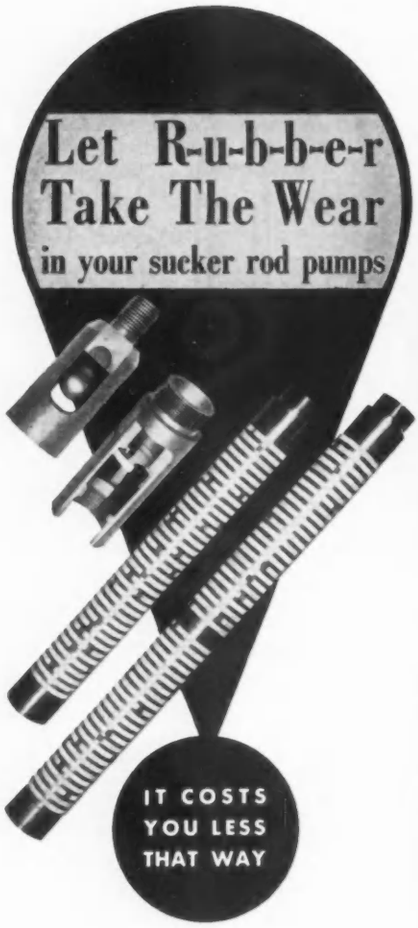
CAPITOL MANUFACTURING CO.,
Division of Harsco Corporation, Columbus, Ohio.

SPECIFY CAP FOR ALL FITTINGS

SOLD ONLY THROUGH RECOGNIZED DISTRIBUTORS

CAPITOL

For more data on advertised products, use cards, last page.



! MARTIN RUBBER & DUCK RINGS give excellent life in dirty abrasive fluids . . . high or low gravity . . . much or little water . . . shallow or deep wells. They last for years in the easier pumping wells. Replacement rings cost comparatively little.

! MARTIN PLUNGER BODIES, precision grooved, drilled and threaded (no underneath fluid passage), usually last for years. Tube or barrel costs are often cut in half.

! The replaceable SYNTHETIC RUBBER GUIDES in MARTIN CAGES last longer than any metal, and the cushioning of the ball increases your ball & seat life. Results are often truly amazing. (Patent No. 2,591,174)

Write for our new catalog or see it in the Composite (24th Edition). All products sold thru supply companies.

JOHN N. MARTIN
Manufacturer
9 W. BRADY STREET • TULSA, OKLAHOMA

Suppliers' notes

BJ Service Engineers Meet

Top BJ Service field and lab engineers held their semiannual meeting in Arlington, Texas, to exchange information about newest techniques in downhole servicing of oil and gas wells. Attending were (standing, left to right): M. B. Riordan, vice president engineering and development; E. M. Cloughly, J. A. Karelitz, J. J. Davis, G. L. White, C. H. Mohr, V. C. White and E. C. Kendall; (sitting, left to right): J. W. Latham, S. A. Maley and J. L. Buster.

Robert B. Hill has been appointed wellhead sales supervisor for the Southern Region and **Robert H. Caldwell** for the Northern Region of **The National Supply Division, Armco Steel Corporation. C. L. Griffin,** formerly general sales manager of the **Oil Tool Division of Chicago Pneumatic,** has been named general manager of that division. Griffin will continue his close supervision of the sales activities as well as other phases of the Oil Tool Division operations.

James E. Grady has been named division manager at Tulsa for **Welex,** a **Division of Halliburton Company.** Also, **George Harcourt** replaces Grady at Dallas as area sales manager.

R. L. Armstrong has been named area manager of the Rocky Mountain Area of the **Oil Well Supply Division of U.S. Steel Corporation.** Also, **William Miskimins** has been named store manager-store products, Dallas; **William A. Slocombe** appointed manager-tubular sales, Calgary, Alta; **W. A. Weir,** named vice president-sales, located in Dallas; **M. F. Hazel,** named executive vice president, headquartering in Dallas, and **James E. Chenault, Jr.,** named area manager, located in Calgary.

W. Kelso Woodward has been appointed to the position of manager-sales administration of **Axelson-Garrett, Division of U.S. Industries, Inc.**

Michael C. Malloy has been recently appointed Western Divisional sales manager, Lubricated Plug Valve Division for **Walworth Company.**

Frank T. House has been appointed sales service manager at **Bucyrus-Erie Company.** In his new position, House will be in charge of field service, parts sales, dragline bucket sales, sales promotion and claims.

Ellis E. Branson has been appointed sales representative in the tri-state area of Illinois, Kentucky and Indiana for **Bradord Motor Works.** Branson will office in Fairfield, Ill.

J. (Tiger) Hood has been elected president of **Tube Process Corporation.** Hood has 24 years experience in the drilling and production phase of the oil industry. He is a member of AIME, API and TIPRO.

H. H. Rainey has been appointed as assistant to **C. M. Moore, Jr.,** Eastern Hemisphere vice president of **Geophysical Service, Inc.,** the exploration subsidiary of **Texas Instruments Incorporated.**

L. V. Page, salesman for **Jones & Laughlin Supply Division** at Casper, Wyo., has been transferred to Rock Springs, Wyo. Other personnel reassigned are **J. B. Knauth,** salesman at Liberal, Kan., assigned to the Oklahoma City sales office; **H. R. Long,** formerly store manager at Brookhaven, Miss., has been assigned as salesman at Natchez, Miss.; **Louis G. McKnight,** sales trainee at the Perry, Okla., store, has been promoted to salesman there; **John J. Joyce,** sales trainee, Hobbs, N.M., is now a salesman, and **Raymond R. Brown,** sales trainee at Houma, La., has been promoted to salesman and assigned to Liberal, Kan.

Alex W. Francis, Jr., vice president and director of **National Tank Company,** has been elected president, succeeding **Jay P. Walker,** founder and president of National since 1926. Walker will remain chairman of the board. **Judson D. Lowd** succeeds **C. G. Wells** as executive president. Wells was elected vice chairman of the board and chief executive officer.

Brian A. Cooper has been appointed regional manager of sales for **The National Supply Company, Limited.**

Demand Careful Equipment Investment

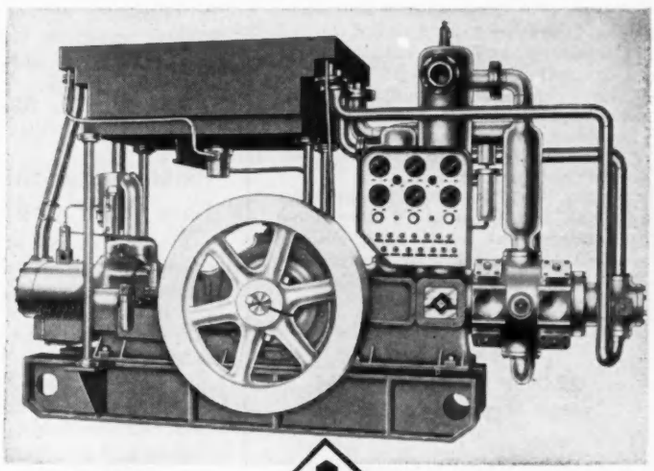
These three new Ajax Full Dollar Value Single Engine Compressor Units have been designed to help you buy closer to your actual needs with a reasonable margin of power reserve.

DPC-60 — 60-HP
DPC-80 — 80-HP
DPC-115 — 115-HP

Equipment investment costs are more critical today than ever before.

Let Ajax engineers work with you to determine your real needs and minimum investment for maximum returns from equipment and equipment investment.

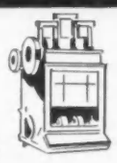
Send for detailed technical specifications brochure today.



THE *NEW* DPC-60 ENGINE-COMPRESSOR UNIT

AJAX

AJAX COMPRESSORS



AJAX . . . also builders of ENGINES . . . PUMPS

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Oil Field Distributors

- The National Supply Co. — Pittsburgh, Pennsylvania
- Bethlehem Steel Co. — Supply Division, Tulsa, Oklahoma
- Mid-Continent Supply Co. — Fort Worth, Texas

WORLD OIL'S **Trading Post** CLASSIFIED ADVERTISING

RATES: Regular Classified (undisplayed) set in this size type: 20 cents per word. Minimum charge $4. Blind box address in our care counts six words. Replies forwarded without charge. **Display Classified ads,** set in suitably larger type with ruled border, $13.50 per column inch. Ten percent discount for two or more insertions of same copy in consecutive issues. **All Classified ads payable in advance.** Copy deadline: Twelfth of month preceeding date of issue. Send copy and checks to: Trading Post Classified Section, World Oil, P. O. Box 2608, Houston 1, Texas.

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8" and 10" used or new surplus steel pipe couplings, 8 thd., with or without dutchmen, any quantity, any area. Immediate inspection & prompt pickup with our own trucks. Write, wire or phone collect:

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Reservoir Engineers

The Operating Companies of the Oil Consortium in IRAN have openings for qualified Reservoir Engineers possessing not less than 8 years post-graduate Petroleum Engineering experience, the last 5 of which should have been devoted to specialized reservoir engineering functions.
Salary, $13,550-$16,000 net after income tax. Biennial 72 days home vacations plus travel time, housing available, families may accompany. Replies will be held in confidence, write:

Box 518-H
RADIO CITY STATION
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FOR SALE

■ 100,000 acres of Ohio and West Virginia Oil and Gas Leases in Appalachian Basin Area for immediate sale in the multi-million acre lease play scattered in and through major companies' holdings, specializing in 50 to 60 thousand acre blocks. David Law, 716 Union Trust Building, Parkersburg, West Virginia.

Manuscripts Wanted

Have you written a book you would like to have published? Do you have an idea or an outline that you would like to talk over with a publisher? Gulf Publishing Company, publishers of World Oil, Petroleum Refiner and Pipe Line Industry magazines, and numerous technical books, is actively seeking trade and technical manuscripts for publication by its rapidly expanding Book Division. For further information write to Manager, Book Publishing, Gulf Publishing Company, P. O. Box 2608, Houston 1, Texas.

Suppliers' notes

Jim Milsted has been appointed sales engineer for the Oil Tools Department of **Avondale Shipyards, Inc.'s** Harvey "Quick Repair" Yard. Milsted's new position with Avondale Oil Tools will take him to Houma, Leeville, Morgan City and Venice, La., but most of his time will be spent in the vicinity of New Orleans.

Kenneth F. Williamson has been named vice president and product manager-valves for **Grove Valve and Regulator Company,** subsidiary of Walworth Company. Prior to his new appointment, Williamson was assistant sales manager for the Oakland, Calif., headquartered company. Williamson will remain based at Oakland.

K. F. Williamson

Wm. G. (Bill) Rudd has joined **Bovaird Supply Company** as tubular sales manager, a newly created position. Rudd will headquarter in Bovaird's general offices in Tulsa. He will direct the sales of all tubular products throughout the company's 28 offices and stores in Oklahoma, Colorado, Illinois, Kansas, Louisiana, Mississippi, New Mexico and Texas.

Plastic Applicators Opens New Plant and Laboratories

Plastic Applicators, Inc., recently opened a new Houston-area office and laboratories bringing to a total of four plants located in Houston, Odessa, Texas, Harvey and Morgan City, La.

Major activity of Plastic Applicators is applying corrosion and paraffin-resistant plastic coatings to oil field pipe. In addition, the firm has separately operated divisions that provide other services and products. These divisions include Pipe Inspectors Division, which inspects new and used tubular goods; Rubber Applicators Division, manufacturers of molded rubber products and applies rubber tank linings; Plastronics Division, producers of electronic products and instrumentation and provides engineering consulting services, and Cementcap Division, which applies internal cement linings to oil field pipe.

BUSINESS SERVICE

■ FINANCIAL—Investment Banking Houses and Underwriters reached. Confidential. You can send the details of your proposition direct or thru your attorney to Consultant 817-51st Street, Brooklyn, N. Y.

SITUATIONS WANTED

■ Sacramento Valley (California) exploration geologist. Experienced all phases gas exploration, subsurface geology (major company). World Oil, Box 226-W, Houston, Texas.

Philip D. Arterburn (left) and A. C. Allyn (right) announced change in control of Eastman Oil Well Survey Co.

Artnell Co. Acquires Control of Eastman

Artnell Company, Chicago, has acquired control of the Eastman Oil Well Survey Co. The announcement was made recently by A. C. Allyn, president of Artnell, and Philip D. Arterburn, Eastman president. Arterburn remains as president of Eastman. Eastman's headquarters will remain in Denver.

Atlas Bradford Purchases Jeddy D. Nixon Company

The Atlas Bradford Company has bought out Jeddy D. Nixon Co., Inc., in Houston. In making the announcement last month, Atlas Bradford President Donald W. Mackie, Jr., also said two of the Atlas Bradford divisions—Hardy-Griffin Engineering Corp. and Atlas Pipe, Inc.—are consolidating their manufacturing plants.

The Nixon firm was acquired from Jeddy D. Nixon, Sr., owner of the company and developer of the Pump Through sucker rods.

Baash-Ross Division Opens Rental-Service Locations

The Baash-Ross Division of Joy Manufacturing Company recently opened two new rental and service locations. One in Wooster, Ohio, and the second in Edmonton, Alta.

A. J. (Gene) Heath has been named in charge of the operation in Ohio. Assisting Heath are Hubert (Buck) Hasler, Jr., and Lester Davis, warehouseman. The three men moved from the Indiana, Pa., office which has been closed.

In Canada, Ross Himmelreich has joined the Baash-Ross Division to head the company's new rental and service location there.

HOMCO Opens 2 New East Texas Locations

The Houston Oil Field Material Company, Inc. announces the opening of two new locations in East Texas. The new facilities are at Frankston and Longview.

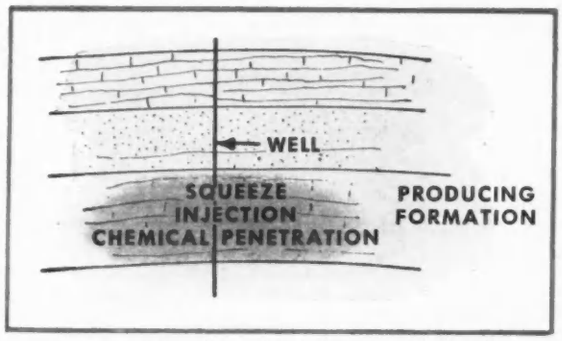
A full line of fishing and cutting tools are maintained as well as oil well rental equipment such as drill pipe, drill collars, kellys and blowout preventers.

Visco Squeeze Treatment Chemicals Designed to Fit Varying Well Conditions

Corrosion Control Lasts, Costs Less with New Visco Formulas, Methods

Squeeze treatment in producing wells continues to grow in importance as an economical, long-term method of obtaining effective corrosion control. It is simply the pressure injection of corrosion inhibitor chemical into the producing formation, from which it is released in approximate proportion to produced fluid volume over a period of time—anywhere from two to sixteen months.

Visco has found squeeze treating of sufficient interest to producers to justify development of specialized chemicals and techniques to permit most effective use of the method.



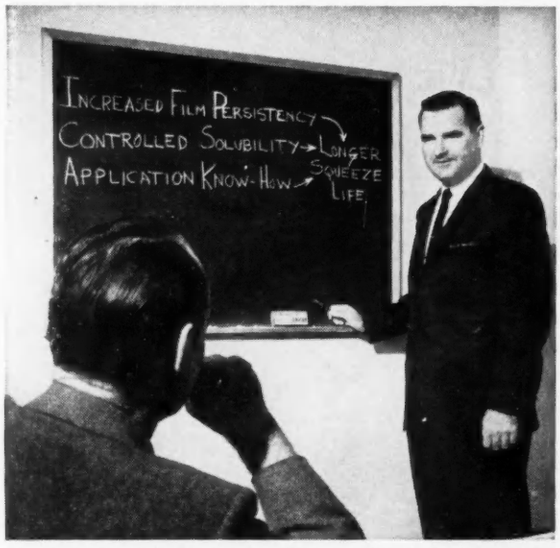
Squeeze technique forces chemical corrosion inhibitor into formation around well bottom. Chemical is carried back with produced fluid. The excellent film persistency of Visco squeeze treating chemicals assures long-lasting, low-cost well protection.

Effects of Formation

Producing formation composition, porosity permeability and position can have an important bearing on the success of squeeze treatment corrosion control . . . They are important considerations in the development of special Visco formulas for this purpose.

Determining Chemical Type

As with any operation affecting producing formations, experience is the most dependable guide. Chances are great that the conditions you have in your area have been closely paralleled by other Visco squeeze treating experience. Further, Visco Formulas such as



Visco's P. H. Mallette, Product Manager for Corrosion Control Chemicals, discusses factors considered important in assuring effective squeeze treatment.

new 939, 956, and 990, were developed to broaden the effectiveness of corrosion control with squeeze treatment, and so are a big help in pinpointing the best chemical and method to apply to specific well characteristics.

Field Experience

Squeeze treating can offer some substantial cost and time advantages for effective corrosion control in many types of producing wells . . . BUT, probably more than any other treating method, squeeze treatment demands skill and experience, as well as effective chemicals, to assure success. No one is better equipped than Visco . . . *we* firmly believe no one else can do as well for you.

Help, Now

Visco action toward being useful in your activities is as close as your phone—and nearly as quick as picking it up. Your move.

VISCO PRODUCTS COMPANY
Incorporated
A subsidiary of Nalco Chemical Company
P.O. Box 87 Sugar Land, Texas

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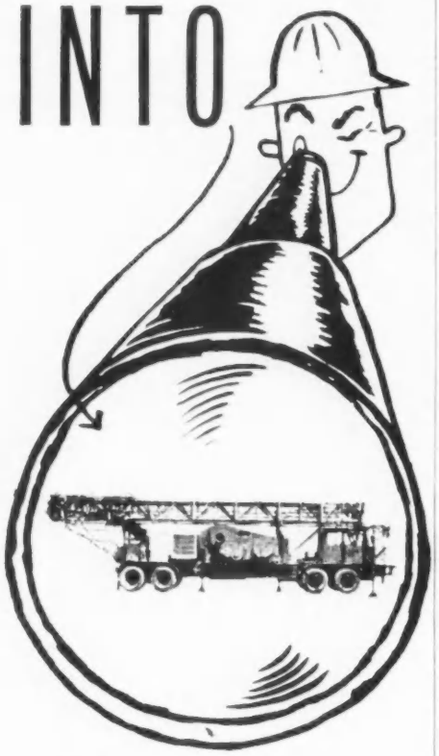
Nalco Italiana, S.p.A., Rome, Italy
Nalco de Mexico, S.A. de C.V., Mexico, D.F., Mexico
Nalco de Venezuela, C.A., Caracas, Venezuela

Visco® . . . Serving the Oil Industry through Practical Applied Science

Visco CHEMICALS
Visco SERVICES

For more data on advertised products, use cards, last page.

WORTH LOOKING INTO



Get the facts about—

WINCHMOBILE

Before you buy get the facts on light weight...low cost...long life Wilson Winchmobile with the cross mounted engine which saves moving parts and increases hp to the drum by 20%!

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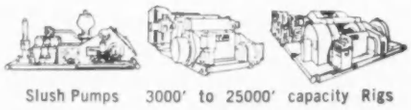

Slush Pumps 3000' to 25000' capacity Rigs

SQUEAKS

From the Bull Wheel

WORLD OIL

"Mostly it's dull routine, but this promises to be a fairly eventful day."

A Wabbit Called Peter

A new Bible teacher was testing the knowledge of her three-year-old class.

Who was Paul? Silence.

Who was Matthew? Silence.

Who was Moses? Silence.

Who was Peter?

After a pause, a little boy timidly raised his hand and asked, "Wasn't he a wabbit?"

Come Clean, Now

"Why didn't you report the robbery at once?" an insurance agent asked a woman claimant. "Didn't you suspect something when you came home and discovered all the drawers opened and the contents scattered?"

"Not really," she replied, "I thought my husband was looking for a clean shirt."

Clever, These Camels

We read somewhere that 5,000 camels a year are used to make paint brushes. It's remarkable what they can teach animals to do these days?

Such Is Wife!

"I take my wife every place . . . but she always finds her way back!"

That's Politics

Protesting Citizen: I wouldn't vote for you if you were St. Peter himself.

Candidate: If I were St. Peter, you wouldn't be in my district.

Bedtime Story

6-year-old: "Me slept with daddy last night."

Teacher (correcting): "No, I slept with daddy last night."

6-year-old: "Then you must've come in after I went to bed."

Quite Contrary

Mary had a little lamb
Some champagne and dessert
Then gave the guy a bum address
The dirty little flirt

Some Sport!

Then there's the fellow who says his favorite sport is fishing through the ice . . . for olives.

CUT STUCK SAND LINES INSIDE TUBING

KINLEY SAND LINE CUTTER

J. C. KINLEY CO., Licensees

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GLENDIVE, MONTANA—C. A. White....EM 5-3833
HOBBS, NEW MEXICO
Horne Well Service Co.....3-5396
KILGORE, TEXAS
Davis-Kemp Tool Co., Inc.....5541
LIBERAL, KANSAS—Rainbo Service...Main 4-3598
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Rainbo Service Co.....PL 6-2530
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Luccous Service & Eqpt. Co.....MU 2-8311
NATCHEZ, MISSISSIPPI
Davis-Kemp Tool Co., Inc.....2-3021
NEW IBERIA, LOUISIANA
Klein-Deco Wire Line Service.....EM 9-6632
OKLAHOMA CITY, OKLAHOMA
Rainbo Service Co.....ME 4-2131, ME 4-0105
STERLING, COLORADO
Cable Drilling, Temp. & Well Serv. Co...LA 2-4761
VIDALIA, LOUISIANA
Davis-Kemp Tool Co., Inc.....ED 6-4224
WHITTIER, CALIFORNIA
Kline Wire Line Co.....OX 3-2731
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Eads Engineering Services, Inc.....766-0931
WILLISTON, N. DAKOTA
C. A. White.....GR 3-6555

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OVER 9″ OF PENETRATION IN HARD BEREA SANDSTONE

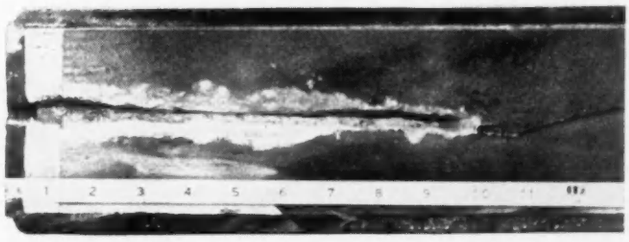
Two, more powerful, deeper penetrating Glass Jet Units are now available from McCullough. They are the improved 25-gram Standard Casing Glass Jets to perforate 4″ OD casing and larger and the improved 35-gram Super Casing Glass Jets for 5½″ OD casing and larger. Both are run in flexible Steel Strip Carriers.

In tests conducted in standard Berea Sandstone targets, penetration for each size was greater than ever before achieved – more than 9″ in these very hard targets and with excellent well flow index.

McCullough Glass Jets are the only expendable jet charges that are relatively junk free. When fired they disintegrate into a harmless powder of silicon and lime. No carrots are formed. Fragments of junk, usually associated with other expendable jet perforators, are eliminated. The Steel Strip Carrier is removed from the well after the gun is fired on the electric wire line.

For deeper penetration – peak production – use improved McCullough Standard or Super Casing Glass Jets on your next job.

The 25-gram Standard Casing Glass Jet is available in 3¼″ OD and 3¾″ OD gun diameters. The 35-gram Super Casing Glass Jet is furnished in 4″ OD and 5″ OD diameters. Perforators may be any length required to perforate several intervals on one run in the well. This is accomplished by leaving blank sections in the length of carrier where perforating is not required.



Standard Berea Sandstone target perforated by 25-gram improved Standard Casing Glass Jet at ½″ clearance. Average penetration of a series of tests – 9.312″. Average entrance hole size – 0.375″. Pressure rating – 20,000 psi. Temperature rating – 300°F.

McCullough
TOOL COMPANY
Los Angeles • Houston • Edmonton
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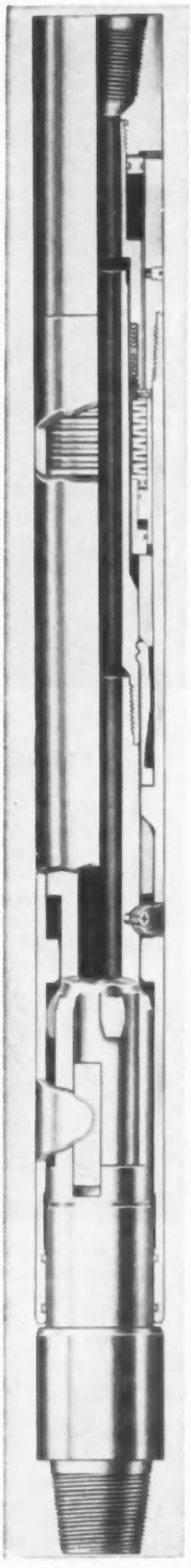
For more data on advertised products, use cards, last page.

NEW equipment and services

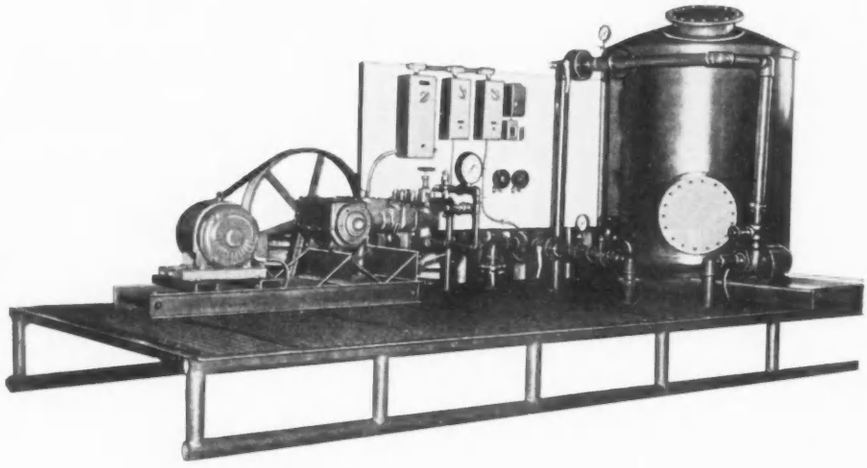


New Type Fishing Jar

This new type of fishing jar combines the advantages of a straight-pull Hydraulic Jar, a straight-pull Mechanical Jar (as "standby") and the controlled releasing action of a positive Safety Joint in the event the fish cannot be freed and it is desired to release the fishing string. There is no risk of the wrong tool being actuated while manipulating the run-in string. Various actions are under complete control of operator.

(Shaffer Tool Works. Supplements data on Pages 4933-5024, 1960-1961 Composite Catalog).

For more data, circle E1 on postcard



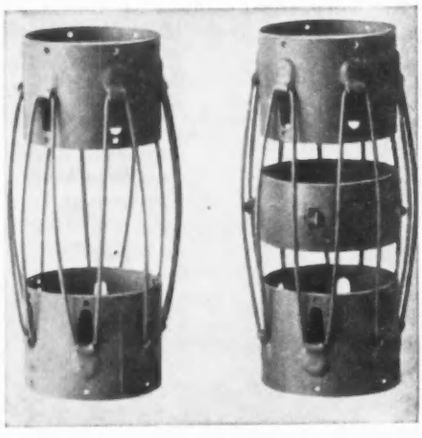
Standard Base Piping Assembly

A standard 8x20-foot skid-mounted base assembly with under-the-floor piping and base fittings for components of waterflood plants injecting from 500 to 2,500 bpd is now being fabricated. Size of inividual components can be varied to meet specific needs.

Advantages cited include lower cost to user while retaining flexibility of component selection. Entire unit is within road transportation limits.

Filter assembly, mounted on one end, rests on steel cross-members welded to base. Injection pump is mounted on separate skid, then the whole unit is welded to base platform. (Atlas Bradford Co.)

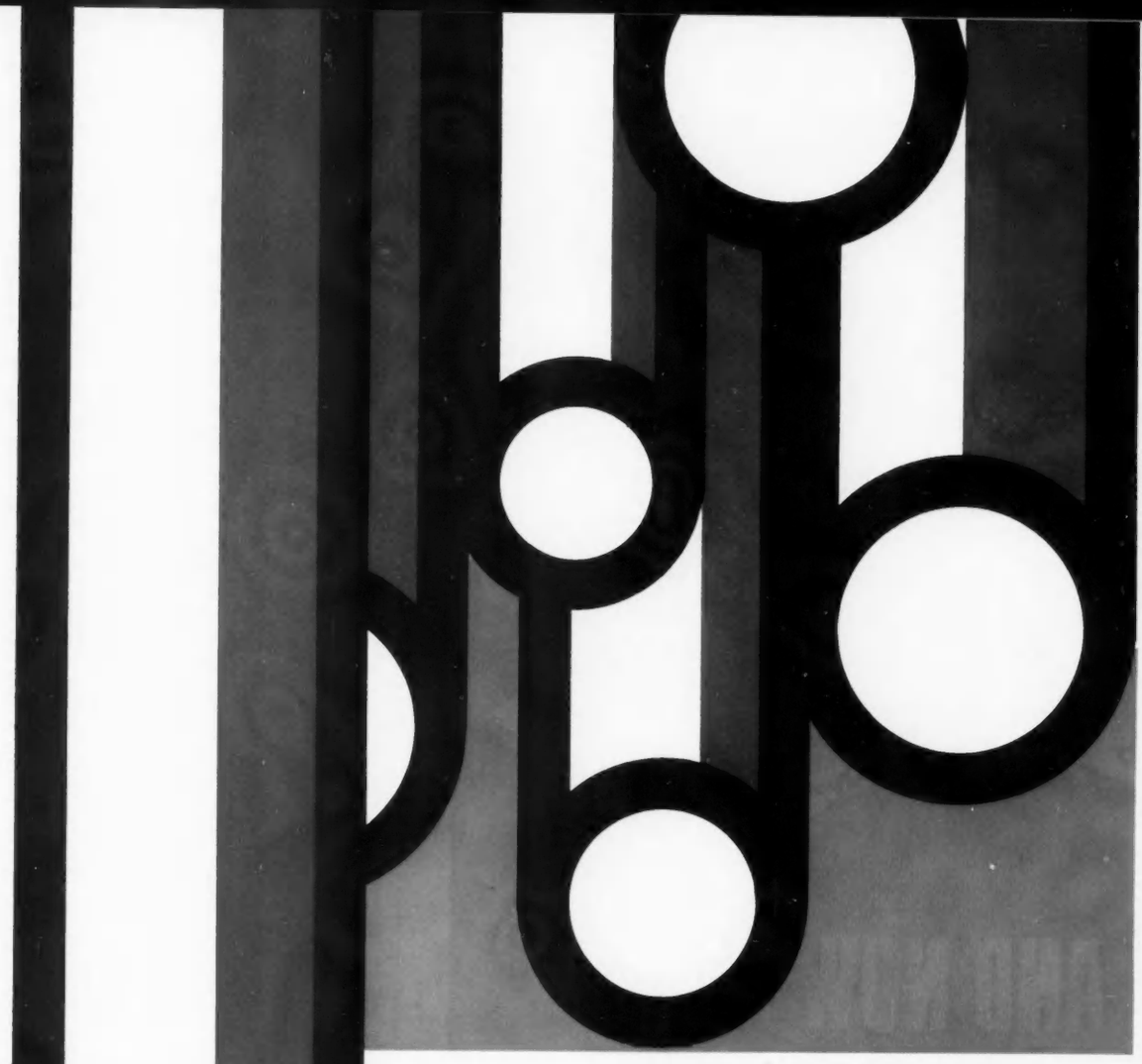
For more data, circle E2 on postcard



New Centralizer

This new Hyflow Guide is a rod spring-type centralizer designed to provide full fluid circulation. Both end collars are flash welded and made without a restictive bead. Designs allows a full 360 degree fluid course over the outside perimeter of the unit. Unit also assits in removing excess hole growth and affords protection to the scratchers. Rod bows are made from one continuous rod with no ends to pull free. (B & W Incorporated. Supplements data on Pages 345-352, 1960-1961 Composite Catalog).

For more data, circle E3 on postcard



For the Progress of Economy and Civilisation

new supply systems made of steel tubes are installed all over the world. Just as indispensable the steel tube has become as structural element.

During the last fiscal year, PHOENIX-RHEINROHR produced approx. 750,000 tons of seamless and welded steel tubes for all fields of application.

- Pipe lines of all sizes for water, gas and oil
- Installation tubes
- Oil country pipes
- Boiler and superheater tubes
- Tubes made of special steels
- Precision and cylinder tubes
- Structural tubes

PHOENIX-RHEINROHR AG

VEREINIGTE HÜTTEN- UND RÖHRENWERKE DÜSSELDORF

GERMANY

With the July 1 acquisition of Red Supply Co., Inc., Houma, Louisiana, we are now better able to serve more people than ever before. We are happy to announce that J. F. "Red" Roth joins us as District Manager in charge of all Rodman operations in Southern Louisiana.

RODMAN SUPPLY CO.

SUPPLY STORES · SALES OFFICES

Home Offices P. O. Box 591
Odessa, Texas

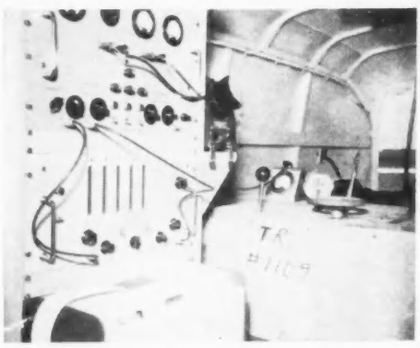
Serving the general oil supply need since 1935
Oil country tubular goods distributor for Jones & Laughlin Steel Corporation and Lone Star Steel Company.

New equipment

New Jet Pipe Cutter

This new Kirby Jet Pipe Cutter has been developed for cutting popular sizes of tubing, drill pipe or casing where unobstructed inside access of the tool is possible. Cutter is a non-conductor wireline operated tool which combines maximum safety and simplicity of operation with clean, uniform pipe cutting, with maximum flare to the pipe OD and without damage to the surrounding casing. (K & G Oil Tool and Service Co., Inc. Supplements data on Pages 3104-3107, 1960-1961 Composite Catalog).

For more data, circle E4 on postcard



New BHP Equipment

This electronic instrument will measure and record bottom hole pressure readings at the surface with a precision of one part in 20,000. Bottom-hole pressure readings are printed on a paper tape as frequently as once every 10 seconds and the instrument can remain in the bottom of the well for an indefinite period of time. As many as 8,000 individual pressure and time measurements can be reported for a 24-hour test period. (Petroleum Engineering Service, Inc.).

For more data, circle E5 on postcard

If it floats,

G&H Offshore
Can Tow It... Anytime

Specialists in Gulf Coast tidelands and deep sea towing. All assignments handled with speed, safety, efficiency and economy.

With diversified marine experience, G & H Offshore operates a modern fleet of diesel tugboats. Seasoned, licensed seamen are working partners in your offshore tow.

Call us today and let us help you plan your next towing job.

DISPATCHER DAY OR NIGHT PHONE Galveston SO 3-4673
Galveston Office SO 3-4331

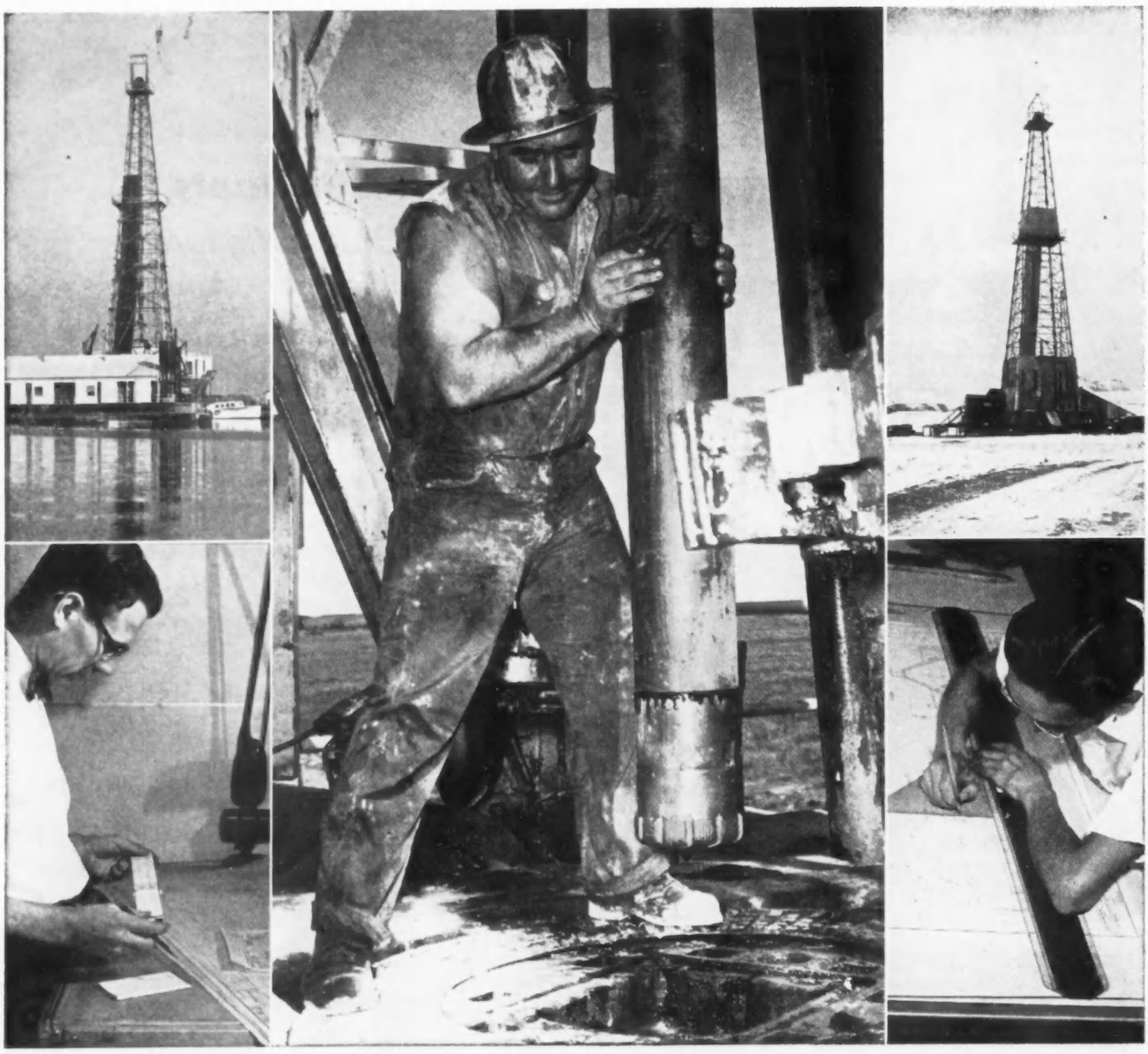
G and H

OFFSHORE TOWING CO., INC.

COASTWISE AND DEEP-SEA TOWING

505 U. S. National Bank Building, GALVESTON

131



Operate at "Less cost per foot"

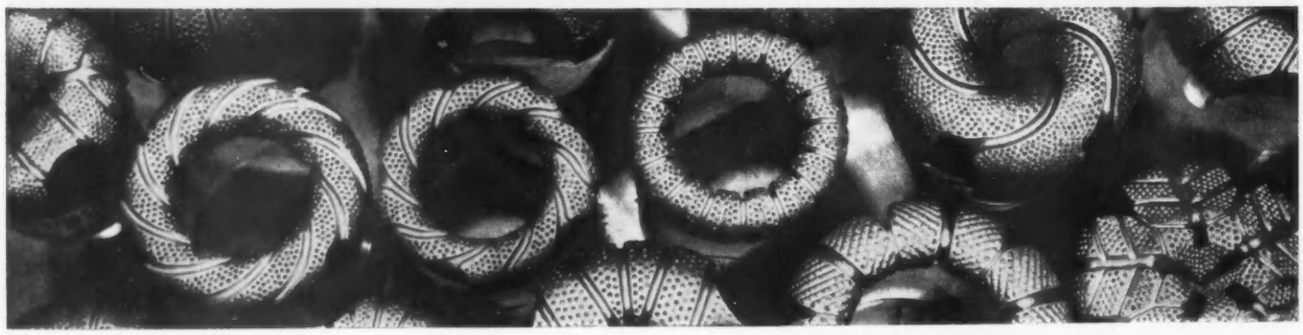
With manufacturing plants throughout the world Christensen can design and deliver your "engineered" diamond bit, on time, regardless of your job location.

"Less cost per foot"

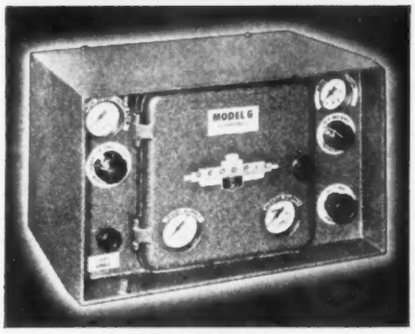
CHRISTENSEN DIAMOND PRODUCTS

MAIN OFFICE AND PLANT 1937 SOUTH 2nd WEST
SALT LAKE CITY, UTAH

SERVICE FROM WORLD-WIDE SALES OFFICES AND MANUFACTURING PLANTS



MORE HOLE PER DOLLAR



THE GEODRIL MODEL G COMPACT AUTOMATIC DRILLING CONTROL

GIVES YOU:

- Longer Bit Life
- Better Coring and Reaming
- Straighter Hole
- Reduction in Twist-Offs

SAVES YOU:

- Costly Downtime
- Equipment Wear
- Time to Contract Depth
- Dollars per Day

Considerable savings to the contractor in both time and money can be obtained through any of these.

Today's highly competitive drilling situation makes it essential that the optimum drilling rate be maintained from grass roots to total depth. The Model G Geodril Automatic Driller provides this assurance while maintaining safe, reliable control of the brake at all times.

If you want more hole per dollar, contact your nearby Geolograph Oil Field Services Office. Ask for Catalog 223.

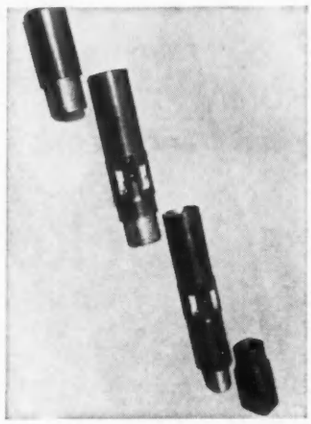
GEOLOGRAPH

OIL FIELD SERVICES

P. O. Box 1276

Oklahoma City 1, Okla.

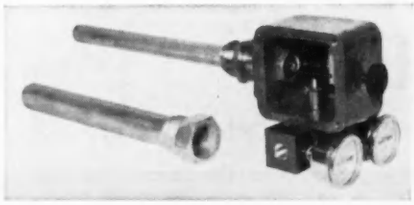
New equipment



New Milling Tool

A new milling tool is designed to mill out a complete section in just one trip down hole. Windows of any length can be completed in one trip. Other features: multiple sets of knives; full circulation for fast removal of cuttings and effective conditioning of exposed hole; knives underream as they mill, and pressure drop gives clear indication that casing is cut in two. Tools available for milling all sizes and weights of casing from 5-inch, 23# up to and including 9⅝-inch, 60#. (Hunt Tool Co. Supplements data on Pages 2713-2760 & 1848A-1848D 1960-1961 Composite Catalog.)

For more data, circle E6 on postcard



Temperature Controller

This new temperature controller, known as the Thermo-Regulator, is a glass-metal type controller designed to throttle the temperature within a vessel at a pre-set point. Models are available to provide either pilot or direct type control over ranges from — 100° F to + 650° F or + 650° F to + 1,000° F, and is available with ¾ inch or 1 inch NPT thermowells. Field proven accuracy plus or minus 2°. (Instruments, Inc.).

For more data, circle E7 on postcard

No-Wall-Stick Drill Collars Being eyed by the drilling industry

In the past year the No-Wall-Stick drill collar design has proved itself to be one of the few major improvements in drilling equipment since the introduction of the rock bit.

ENGINEERING ENTERPRISES, INCORPORATED

1200 San Jacinto Bldg.
Houston 2, Texas
CA 8-0386

No-Wall-Stick Drill Collars are available on a rental basis or may be purchased by the operator or drilling contractor.

Pat. Pend.

Rotary Oil Tool Company

"Lockomatic" Regular Type Hole-Opener and Section Mill

"LOCKOMATIC" Expanding Hole-Opener and Section Mill

Rotary "Lockomatic" Means...

ASSURANCE—

Positive locking of the cutters open, assures a full gauge hole in formation and *NO* hen-skinned casing in milling a section. Positive unlocking of the cutters, assures the withdrawal of the tool from the hole.

EFFICIENCY—

Rotary "Lockomatic" tools give maximum performance in the hole, with maximum wear and tear on tools and drilling equipment.

PROGRESS—

Look to Rotary "Lockomatic" for the latest and best in expanding tools.

SAFETY—

Our safety slogan tells the story:

The ROTARY OIL TOOL COMPANY "LOCKOMATIC" Expanding Tools have never been stuck in a hole, due to cuttings fouling the mechanism or failure to unlock. Rotary's "Lockomatic" Casing Section Mill will NOT hen-skin casing in high angle holes.

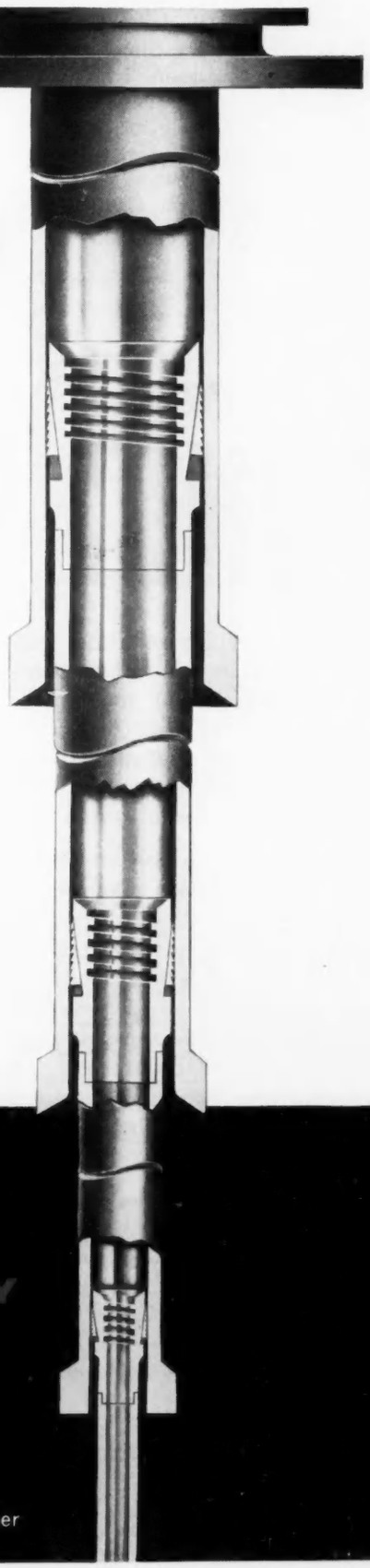
"Lockomatic" MJC Tool (Casing Milling Jet Washing Cementing)

Rotary Oil Tool Company

Serving the industry over 20 years

8655 Whitaker Ave., Buena Park, Calif. • LAmbert 6-4621 • Cable ROTOILTOOL

Standardize on Burns Casing Hangers and SAVE Completion Costs!



Today's allowables make it imperative to reduce the cost of oil well completions. Keep up your present drilling commitments with less investment per well.
Use a Burns Casing Hanger!

The displacement of the slip is arranged to distribute the load uniformly around the water string, giving the water string maximum protection. Suspend on bottom, overlap 100 feet in the protective string and cement the overlap.

ELIMINATE THE HAZARD OF CASING CONTACTING THE WALL OF THE HOLE

Get a uniform annular space around the casing shoe for cementing in high angle holes by suspending with a double Slip Burns Casing Hanger. Suspended casing centralizes itself and is perfectly aligned with the axis of the hole, in tension, free of bends, assuring a good cement job.
Each slip carries its own load, independently distributing the load equally over the entire slip area.
Circulation grooves milled in the body reduce the velocity around the hanger, assuring a better cement job.
Cementing the well can be done either before or after the hanger is released.
SAFETY: The double-slip Burns Casing Hanger can be set with the proper stretch on the casing, even though the pipe is frozen, by rotating the running-in string six turns to the right. This allows the slips to raise against the protective string and suspend the frozen casing properly.

Write today for complete product catalog

BURNS TOOL COMPANY

Sold through leading supply houses

8346 Salt Lake Avenue, Bell, California LUdlow 2-6209

Branch office:
217 Walker Road
Farmington, New Mexico

Field service points:
Bakersfield, Taft,
Coalinga, Ventura,
Santa Maria, Casper

Combo Spacer-Cleaner

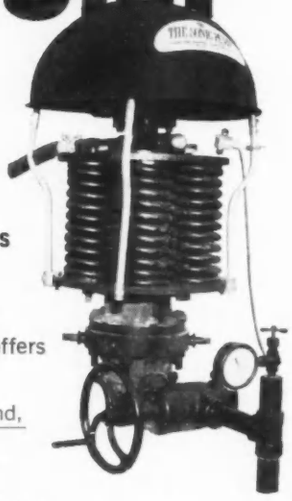
This new tool combines features of company's Recipo Wall Cleaner and Tubing Spacer into one unit to provide improved reciprocating wall cleaner and spacer for single or multiple strings in tubingless completion wells. Function of the cleaner is to remove undesirable filter or mud cake from wall of the bore hole for better cement bonding. (Halliburton Co. Supplements data on Pages 2301-2424, 1960-1961 Composite Catalog)

For more data, circle E8 on postcard

Progress Report...

SONIC PUMP

Two years ago Johnston Testers began a comprehensive research and development program for the Sonic Pump. Field tests defined the areas of application and were so successful that the pump is now considered a proven product.



The Sonic Pump is presently available for tubing depth ranges of 400-4000 feet, and offers these major advantages:

- √ demonstrated ability to pump paraffin, sand, mud, gyp and other agents detrimental to conventional pumping equipment;
- √ requires no sucker rods or subsurface pump;
- √ simplicity of installation;
- √ minimum lubrication and maintenance;
- √ flexibility of operation.

JOHNSTON TESTERS

P. O. Box 98, Houston 1, Texas

321-50th Avenue S.E.—Calgary, Alberta

I would like more information regarding application of the Sonic Pump.

Name_____ Title_____

Company_____

Address_____

New literature

To get your copies, circle key numbers on postcard and mail to WORLD OIL

Hydraulic Fracturing

Available from Halliburton Company is a "Fracplan" brochure which discusses an advanced scientific approach to the problem of planning efficient hydraulic fracturing treatments. Nomographs, propping agents, procedures, capacities and other data are discussed. Examples given.

To get a copy, circle E9 on postcard

New Cement Additive

A brochure titled "Silica Flour" has been released by Halliburton Company. Brochure explains a new additive designed to maintain low cement permeability and to reduce strength retrogression in cementing deep, hot wells. Performance data and resume of representative field jobs are included.

To get a copy, circle E10 on postcard

Sand Control

Halliburton Company has published a brochure titled "Halliburton Methods of Sand Control," which deals with five methods for controlling incompetent or unconsolidated producing formations. Both chemical and mechanical approaches to sand control are discussed. Technical data.

To get a copy, circle E11 on postcard

Dowell Foaming Agents

Dowell Division of The Dow Chemical Company has recently released a two-page product data sheet discussing G2 and G4, Dowell foaming agents. Data sheet includes information on what they are, what they do, where they are used, advantages of using foaming agents, their physical properties, case histories, packaging and availability and their prices.

To get a copy, circle E12 on postcard

Auxiliary Drawworks Drive

Drilling operations with the National Auxiliary Drawworks Drive are graphically illustrated and explained in Bulletin No. 521, issued by National Supply Division of Armco Steel Corporation. Photographs and diagramatic views also are included.

To get a copy, circle E13 on postcard

Continuous-core drilling rig

is new oil exploration tool

Dependable International power helps prove continuous-core concept in year of field testing

Here's a follow-up report on continuous-core drilling conducted by Strato Drill, Inc., Houston, Texas. A year of drilling in a wide variety of formations, at depths to 3,000 feet, has shown the new method to be completely successful as an aid to the geologist in obtaining more detailed, more reliable subsurface information. The prototype drill has proved that savings can be expected because of reduced hole size and pump size; also less hydraulic pressure, pump volume and pump horsepower are required.

Economy of operation and reliability of equipment were of prime importance in this experiment, and it is significant that the driller chose International power. Two heavy-duty International V-8's on Strato's No. 1 performed economically and dependably throughout the extensive testing period. Your power requirements, too, can be handled with a call to your nearby International Engine Distributor or Dealer. He'll be happy to give you full information on any of the 35 models—16.8 to 385 max. hp—stripped engines to complete power units. Call him soon!

Strato Drill's Rig No. 1 on location in Glasscock County, Texas. Loop over mast is core-return tube through which cores are circulated to surface as soon as they are drilled. Reverse circulation is the key to the continuous-core method. Fluid is pumped down annulus between drill pipe and core tube; it goes out into the open hole just above the bit, then rises to surface through core tube. Core segment comes up in ascending fluid as a free body, with little mechanical damage. Pipes are rotated by power swivel on mast. International engines pump from two mud tanks. One mud is especially formulated to be used for drilling fluid. The other, heavier mud, formulated to protect hole walls, is introduced into the hole annulus, and is also held in reserve for killing a gas blow or controlling high pressures. Core recovery has been 100% in most cases.

INTERNATIONAL®
ENGINES

International Harvester Co., 180 North Michigan Ave., Chicago 1, Ill.
A COMPLETE POWER PACKAGE

INCREASE YOUR
PRODUCTION
With A
MILLER
SAND PUMP

Miller offers a complete range of sizes including the new 2" OD for Slim Holes. 2" OD pump is also available in Rod Type pump with 1 1/16" API pin. Miller Sand Pumps are world famous. For fast, easy cleanout, fewer round trips and less downtime choose Miller.

SAND PUMP SIZES

OD—2, 2½, 3, 3½, 4¼, 5, 5½, 7 in.

Lengths—20, 25, 30 ft. for 3" OD and larger pumps. 20 and 25 ft. for 2½" pump. 20 to 24 ft. for 2" pump.

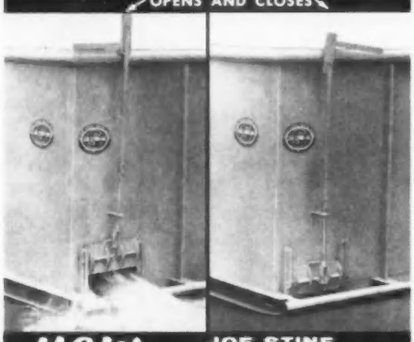
Composite Catalog, Page 3688
Write for descriptive price list

MILLER SAND PUMPS

Miller Sand Pump Co.

General Offices, Box 4516
Oklahoma City 9, Okla.
Phone OR 7-4884
EXPORT OFFICES
30 Rockefeller Plaza
NEW YORK CITY 20, N. Y.

An Easy Swing
OPENS AND CLOSES



NEW JOE STINE CLEANOUT GATES

QUICK . . . POSITIVE SEALING . . . SAFE

This effective gate is a new addition to the Stine mud tank line. It may be installed either on the inside or outside of the tank.

FEATURES: Designed especially for heaviest mud. Closes quickly, won't get operator wet, requires no special tools. Positive sealing due to cam operation. Replaceable seal ring. Gate flush with bottom of tank. Safety locks in closed position. Ease of operation.

Write for our new Bulletin 60-B

JOE STINE INC. HOUSTON, TEXAS

JOE STINE
INCORPORATED
6022 Cullen Boulevard
Houston 21, Texas
P. O. Box 14471
RI 7-3600

New literature

Extreme Line Casing

The Youngstown Sheet and Tube Company's orange band Extreme Line casing is described in a new brochure. Dimensions and performance properties are clearly described in a two-page, easy-to-read chart.

To get a copy, circle E14 on postcard

Hydraulic Pumping Catalog

Kobe, Inc., has issued a 36-page catalog which contains a full description of Kobe hydraulic systems. Two types of pumping installations-afixed type and the Kobe Free Pump—are explained in detail. Pump selection tables simplify the ordering of the proper pumps.

To get a copy, circle E15 on postcard

Water-Gel Temporary Plug

A two-page product data sheet is available from Dowell Division of The Dow Chemical Company on its new Water-Gel Temporary Plug which may be injected before and between batches of acid in the acidizing of wells.

To get a copy, circle E16 on postcard

Drill Pipe Inspection

Tuboscope Company now offers a new two-color, four-page brochure describing service-induced defects in drill pipe and how they are detected by use of Tuboscope's Sonoscope and other inspection services. Also described is the Tuboscope Analog inspection for new drill pipe.

To get a copy, circle E17 on postcard

Advertisers in this issue

• Dot preceding name of advertiser indicates that detailed data on products and services of the firm will be found in current 24th (1960-61) Revision of The Composite Catalog of Oil Field Equipment.

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• The Youngstown Sheet & Tube Co. 34

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2. For more data on Advertised Products and Services, circle on card the actual page number of the advertisement as listed in the Advertisers' Index on the preceding page.
3. Then, print your name, title, company and complete mailing address and drop the card in the mail. WORLD OIL's Readers' Service Department will promptly forward your requests to the company concerned. The requested information will then be mailed directly to you.

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BOX 2608
HOUSTON 1, TEXAS, U.S.A.

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Circle page number for more information on ADVERTISED products

WORLD OIL Readers' Service Card — **August 1, 1961 Issue***

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E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22

ADVERTISEMENTS—Circle page number of ad for more product information.

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33	34	35	36—37	38	39	40	41	42—43	44	45a	45b	46	47	48	49	50—51	52	79
80—81	82	93	98—99	100—101	102—103	104	105	106	107	108a	108b	109	110	111	112	113	115	116
117	118	119	121	122a	122b	122c	123	125	126	127	128	129a	129b	130—131	132	133	134	137
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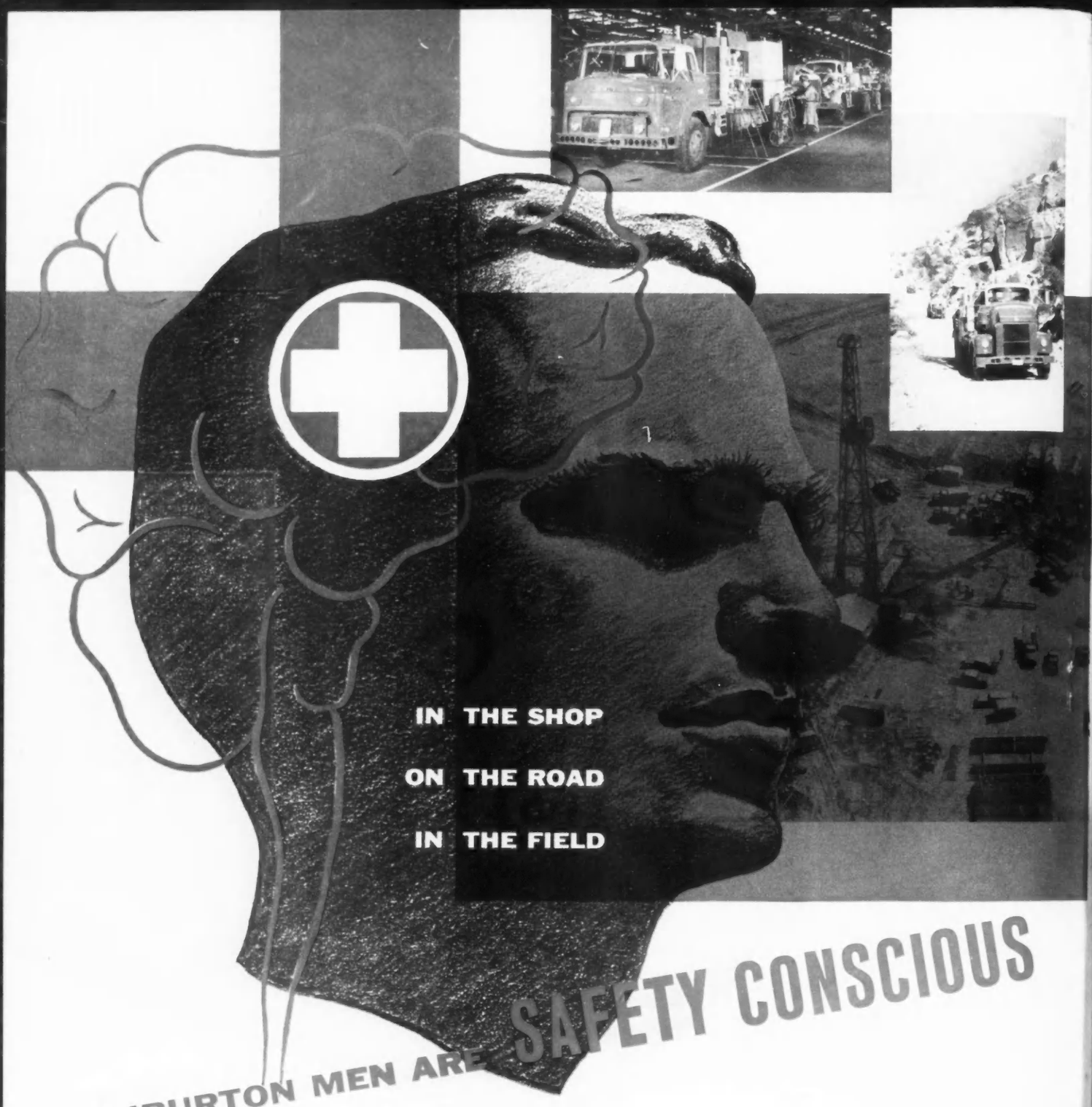

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